PROSPECTS FOR THE POTATO IN THE DEVELOPING WORLD

Centro Internacional de la Papa
(International Potato Center) La Molina
Apartado 5969, Lima-Perú

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An International Symposium on
Key Problems and Potentials for Greater Use
of the Potato in the Developing World

Held at Lima, Peru, July 17-19, 1972

Edited by E.R. French

CENTRO INTERNACIONAL DE LA PAPA
(International Potato Center) La Molina
Apartado 5969, Lima-Peru
1972

Publicado por el
Centro Internacional de la Papa

2a Impresión
Febrero 1973

Impreso en los talleres de
Servicio de Copias Sociedad Comercial
de Responsabilidad Ltda.
Jesús María, Lima-Perú

PREFACE

The need for an international potato center was recognized about two decades ago by leading potato researchers in Europe and North and South America, but efforts to conceive it were not fruitful until a potato program was developed by the North Carolina State University Agricultural Mission to Perú. During four years as leader (coleader with the Peruvian National Potato Program leader) of this program Dr. Richard L. Sawyer promoted the idea, and a special grant by the United States Agency for International Development permitted him to dedicate two years to the task of making it a reality. During those two years "planning funds" were used not only to prepare supporting documentation and to bring about the exchange of ideas with possible funding source representatives, but also to implement programs.

During these planning years the "center" accepted responsibility for the maintenance of the germ plasm collection of the Peruvian Potato Program, coordinated and assisted a collection trip in Perú and Bolivia, promoted and supported programs for the selection of resistance to important pests and pathogens, and future staff members were either sponsored for advanced education or training, or were selected and oriented so that they would be ready to make rapid contributions when they joined the staff.

The most significant steps during these planning years were: i) the signing of an agreement on the 20th day of January 1971 by representatives of the Ministry of Foreign Relations of Peru giving the Center legal status and special privileges, and of North Carolina State University as the cosignator lending its moral support, and ii) the handing over to the Center, by the Peruvian Ministry of Agriculture, of the building (that quarters the Center staff and laboratories) and the land on which the other facilities are being built, which took place on January 25, 1972.

Hence, when the Centro Internacional de la Papa became established among the family of centers upon receiving the blessing of the Technical Advisory Committee of the Consultative Group on International Agricultural Research, it had already undergone a modest growth. By February

1973 the following facilities will be operational: Four screenhouses and head-house; general storage building; soil and pot storage and treatment site; Virology, Mycology, Bacteriology, Nematology and preparation laboratories; and offices to house the 24 technical staff members and administrators.

This rapid growth demanded more guidance than CIP's skeletal staff could provide in the beginning. A Center such as CIP requires the continuing participation of top experts to give program guidance. To bring together some of the leaders who could contribute their skills and concepts to help chart the course of development of the Center, and to announce to them its launching, this symposium was organized. It was held at the Hotel Crillón in Lima-Perú, July 17 to 19, 1972. A portion of the last day was spent visiting CIP's installations at La Molina District, near Lima.

The editing of the proceedings of this symposium was commended to me. I have received much advice and help, but take upon myself the responsibility for what you see. Whatever deficiencies are noted are most likely due principally to my decision to make sure the publication date was not more than six months after the event, which placed a burden on the authors, my staff and I, and the printers. The authors remain responsible for their contributions which were modified in varying degrees by mutual accord. The Style Manual for Biological Journals published by the American Institute of Biological Sciences served as the guide for editing, with minor departures to accomodate the styles and standards of authors who are accustomed to writing for journals that do not follow this manual.

Edward R. French
La Molina

December 6, 1972

TECHNICAL STAFF OF CIP

Richard L. Sawyer	General Director
Juan S. Aguilar	Horticulturist
David K. Baumann	Agronomist
Carlos Bohl P.	Executive Officer
James E. Bryan	Seed Specialist
Javier Franco P.	Nematologist
E. R. French	Bacteriologist & Head, Pathology Dept.
Oscar R. Gil	Controller
Julia Guzmán N. *	Mycologist
Ana María Hinostroza *	Virologist
Zósimo Huamán **	Fellow in Taxonomy
Michael Jackson	Fellow in Taxonomy
Rosa A. Méndez	Pathologist
John Niederhauser	Director of Outreach
Luis F. Salazar	Virologist
María M. de Scurrah	Breeder-Nematologist
Maurie Semel	Visiting Entomologist
Marco Soto P.	Breeder, Post-doctoral
Luis A. Valencia	Entomologist
John C. Vessey	Pathologist, Post-doctoral
Rainer Zachmann	Mycologist

* To join the staff in early 1973. ----- ** On study leave in England.

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LEGENDS FOR PHOTOGRAPHS

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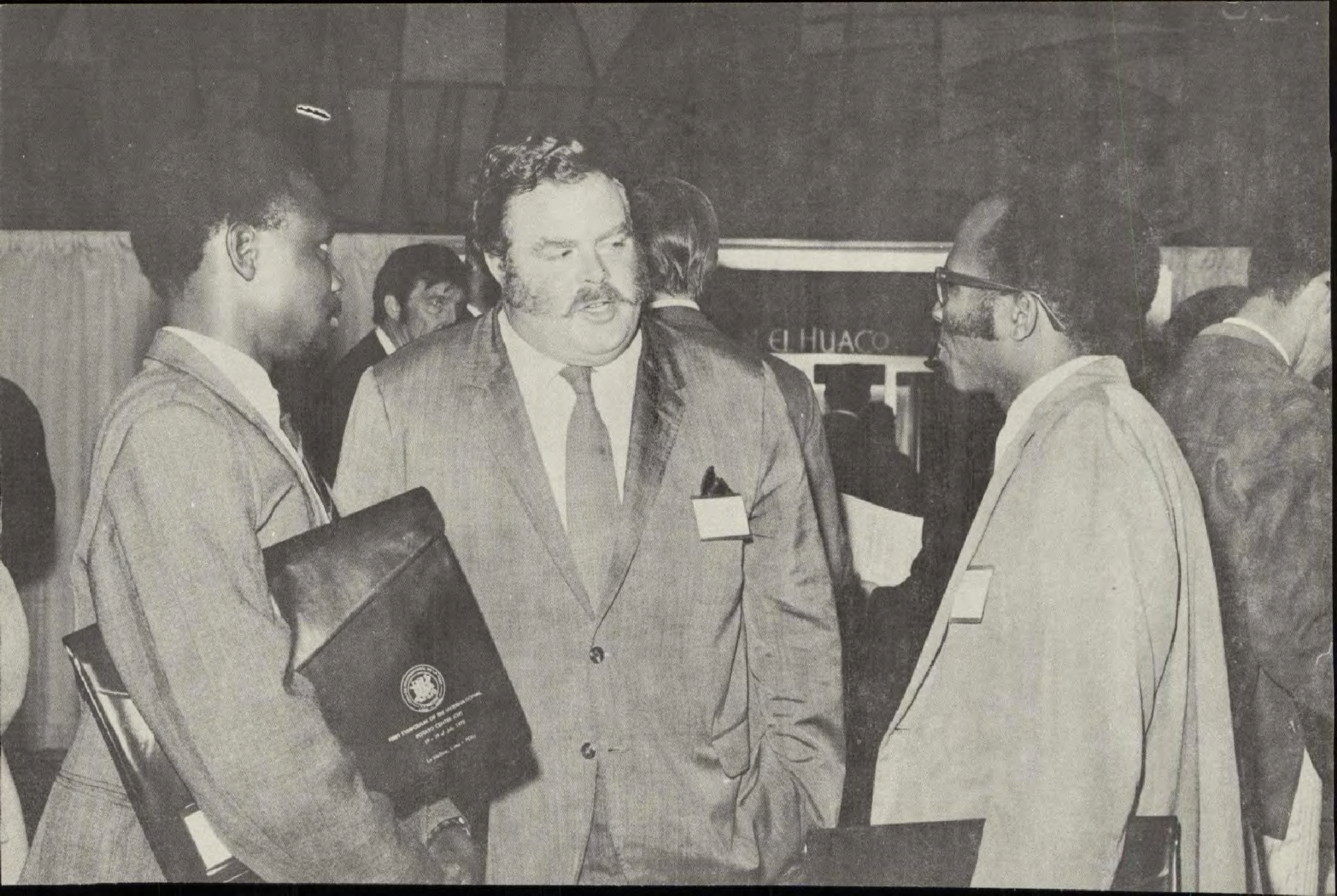
DISCURSO DE INAUGURACION
Primer Simposio del Centro
Internacional de la Papa

INAUGURAL ADDRESS
First Symposium of the
International Potato Center

Richard L. Sawyer
Director General of CIP


EL HUACO

DISCURSO DE INAUGURACION - PRIMER SIMPOSIO DEL CENTRO INTERNACIONAL DE LA PAPA*

Richard L. Sawyer
Director General

En nombre del Centro Internacional de la Papa me es grato darles la bienvenida a este primer Simposio. Sin duda alguna habrán más; sin embargo, éste tiene un significado especial. Anuncia para quienes trabajan en problemas de alimentación mundial, y para la comunidad científica que labora en agricultura, que el Centro Internacional de la Papa ha sido establecido. Los mismos potenciales que han sido desarrollados con el arroz, trigo y maíz pueden ser ahora alcanzados con la papa.

La papa ocupa el cuarto lugar entre los cultivos alimenticios más importantes del mundo. Probablemente, la comunidad científica que trabaja con la papa nunca ha tenido una reunión de envergadura tan internacional como ésta. Está representado aquí el liderazgo científico del mundo que trabaja con la papa. Hemos patrocinado este simposio con el fin de aprovechar los conocimientos de estos científicos al ponerse en marcha a este Centro.

Deseo establecer en forma breve una base para las discusiones que tendrán lugar en las sesiones. ¿Qué es el Centro Internacional de la Papa? ¿Cómo está financiado? ¿Cuál es su objetivo?

El Centro Internacional de la Papa es una institución científica, sin fines de lucro, con autonomía técnica, administrativa y económica, con sede en el Perú. Está dirigido por una junta de directores, cuya composición es internacional y con no más de dos miembros por país.

El Centro Internacional de la Papa es parte de una red internacional de investigación que se está formando. El interés en el desarrollo de una familia de Centros fue estimulado por el éxito alcanzado por el Instituto del Arroz (IRRI) en las Filipinas y por el Centro Internacional para el Mejoramiento del Maíz y el Trigo (CIMMYT) en México.

* Versión inglesa sigue a ésta./English version follows this one.

Actualmente hay siete Centros en el sistema. Cinco ya vienen operando y dos han sido formados este año. Estos Centros son:

Centro	Año de Iniciación	Concentración de Programa
IRRI (International Rice Research Institute) Los Baños, Filipinas	1959	Arroz.
CIMMYT (Centro Internacional para el Mejoramiento del Maíz y el Trigo) México.	1966	Maíz, trigo, cebada, centeno y triticale.
IITA (International Institute for Tropical Agriculture) Ibadan, Nigeria	1967	Sistemas de cultivos para los trópicos húmedos, incluyendo maíz, arroz, tubérculos y leguminosas comestibles.
CIAT (Centro Internacional de Agricultura Tropical) Cali, Colombia.	1968	Sistemas de cultivo para los trópicos enfatizando vacunos, porcinos, yuca, maíz, arroz y frijol.
CIP (Centro Internacional de la Papa)	1971	Papa.
ICRISAT (Instituto de Investigaciones de Cultivos para los Trópicos Semi-Aridos).	1972	Sorgo - Mijo y cultivos alimenticios leguminosos.
Investigación Ganadera para el Africa	1972	Investigaciones en veterinaria y en producción ganadera.

Estos Centros son financiados a través del "Grupo Consultivo para la Investigación Agrícola Internacional". Este grupo lo constituyen fundaciones,

instituciones y agencias de gobiernos que están involucrados en asistencia técnica para la agricultura en los países en desarrollo. Los fondos para el Centro Internacional de la Papa para el año 1972 proceden de los siguientes miembros del Grupo Consultivo: Los fondos flexibles vienen de Dinamarca, EE.UU. y el Banco Mundial. Los fondos destinados a proyectos específicos del Centro vienen de la Fundación Rockefeller, U.S. AID, y los gobiernos de Alemania y Gran Bretaña. Se espera que los fondos del gobierno de Holanda sean asignados para el Centro en los últimos meses de este año. Los fondos procedentes del Grupo Consultivo son principalmente para el Programa Fundamental del Centro. También incluye fondos para parte del Programa de Promoción de Tecnología. Los otros Centros establecidos han desarrollado un gran número de proyectos es-especiales que dan ayuda a los programas regionales y nacionales. El Centro de la Papa también establecerá proyectos especiales similares a medida que va desarrollando su programa. Aunque el Centro está ubicado en el Perú, donde existe una gran variabilidad genética, su programa se extenderá a muchas partes del mundo donde se pueda cultivar y utilizar la papa para resolver problemas de alimentación.

El Programa del Centro se puede dividir en tres partes. Dos de éstas (A y B) involucran la ejecución de investigación, y la tercera (C) la extensión y aplicación de los conocimientos de la investigación en los países en desarrollo.

A. El Programa de Investigación del Centro se concentra en la colección y mantenimiento del germoplasma y su utilización en lo que se refiere a los aspectos principales de resistencia, calidad y producción en los países en desarrollo.

B. Como ya existe una considerable capacidad científica para conseguir el mejoramiento de la papa, dentro de varias instituciones en el mundo, el Centro está estableciendo eslabones con estas instituciones papra proyectos específicos. La filosofía básica es resolver los principales problemas de la papa para los países en desarrollo en donde se pueda hacer la labor más rápida, efectiva y eficiente. El camino de la investigación, hacia la resolución de los principales problemas de la papa incluirá seminarios, simposios y reuniones de trabajo que se conducirán en el Centro ú otros lugares.

C. El Programa de Promoción de Tecnología tiene la responsabilidad de la aplicación de los conocimientos de investigación y mejoramiento de la producción de la papa dentro de los países en desarrollo. Por lo tanto, involucra el desarrollo de programas regionales o nacionales y bue-

nos programas de producción de semilla. Para cumplir en parte esta función patrocinará los siguientes tipos de programa de entrenamiento:

1. Cursillos cuya duración será normalmente una campaña de producción de papa (desde la siembra hasta su cosecha);

2. programas de estudio para el grado Magister Scientiae en el propio Centro;

3. trabajo de tésis de grado avanzado, en el cual los requisitos de residencia y los cursos serán completados en una Institución extranjera, y el trabajo de tésis ejecutado en el Centro;

4. trabajo de post-doctorado, uno o dos años trabajando con material del Centro antes de pasar a un programa nacional;

5. científico visitante - asignación por uno o dos años en el Centro para científicos de un país en desarrollo, para trabajar con el material genético en un proyecto de especial valor para su país. Esto conduce a una conexión permanente entre el Centro y el científico y sus necesidades cuando regresa a su país;

6. más adelante, serán posibles visitas cortas para administradores de investigación en papa en países en desarrollo, con el fin de que puedan reconocer el potencial que pueda tener la papa.

En síntesis, el Centro Internacional de la Papa tiene la responsabilidad de catalizar y conducir investigación para países en desarrollo, como también promover la aplicación de estos conocimientos de investigación para el mejoramiento de la papa en esos países. Este Simposio ha sido organizado como parte de este esfuerzo catalítico.

Un comité de científicos principales que está asistiendo al Simposio y que representa varios países, ha sido nombrado para resumir las discusiones de este simposio, y hacer recomendaciones que puedan ser utilizadas en el desarrollo del programa del Centro. El informe será publicado en los anales de este simposio.

Por favor háganme saber a mí o a cualquier miembro del CIP, si hay algo que podamos hacer para que su viaje al Perú y su participación en el Simposio sea más agradable.

INAUGURAL ADDRESS, FIRST SYMPOSIUM OF THE INTERNATIONAL POTATO CENTER

Richard L. Sawyer
General Director

In the name of the International Potato Center I welcome you to this Symposium. There will undoubtedly be others, however, this one has a special significance. It announces to those concerned with world food problems, and to the scientific community working in agriculture, that the International Potato Center has been established. The same potentials can now be developed with potatoes that are already being realized with rice, wheat and corn.

The potato is the fourth most important food crop in the world. The scientific community working with potatoes has probably never held such a truly international gathering. Represented at this meeting is the best scientific thinking in the world on potato problems. We have sponsored this Symposium in order to take advantage of this knowledge as the program of the Center is activated.

I would like to briefly establish a base for the discussions which will be taking place at the sessions. What is the International Potato Center, how is it funded, what does it expect to accomplish?

The International Potato Center is a non-profit, scientific institution established in Peru, with administrative and economic autonomy. It is governed by a board of trustees whose composition is international with no more than two members from any given country.

The International Potato Center is a part of an international research network being formed. Interest in the development of a family of Centers was estimulated by the successes of the International Rice Research Institute (IRRI) in the Philipines, and the Corn and Wheat Improvement Center (CIMMYT) in Mexico. There are presently seven Centers in the network. Five have active programs and two are being formed this year. These Centers are:

Center	Yr. Initiated	Program Concentration
IRRI (International Rice Research Institute) Los Baños, Philippines.	1960	Rice.
CIMMYT (International Maize and Wheat Improvement Center) Mexico.	1966	Maize, wheat, barley, rye, triticale.
IITA (International Institute for Tropical Agriculture) Ibadan, Nigeria.	1967	Farming systems for lowland humid tropics, including work on maize, rice, tubers and food legumes.
CIAT (Centro Internacional de Agricultura Tropical) Cali, Colombia.	1968	Farming systems for the tropics with emphasis on beef, swine, cassava, maize, rice and beans.
CIP (International Potato Center) Peru.	1971	Potatoes.
ICRISAT (International Crop Research Institute for the Semi-Arid Tropics.	1972	Sorghum-millets, food legumes.
Africa Livestock Research. Kenya.	1972	Veterinary research and livestock production.

These Centers are funded through the Consultative Group for International Agricultural Research. This Group is composed of foundations, institutions and government agencies involved in technical assistance to agriculture in developing countries. Funding for the International Potato Center for 1972 is coming from the following members of the Consultative Group.

Flexible funding is coming from, Denmark, the United States and the World Bank for Reconstruction and Development.

Funding towards specific projects of the Center is being made available by the Rockefeller Foundation, U.S. AID, and the governments of Germany and Great Britain. It is expected that funds from the Netherlands Gov-

ernment will be allocated to the Center later this year.

The funding coming from the Consultative Group is mainly for the Core Program of the Center. It also includes funding for some of the Outreach Program. The other established Centers have developed a large number of special projects which give help to regional and national programs. The potato Center will have similar special projects as its total program develops. Although the headquarters of the International Potato Center is located here in the area where the genetic variability exists, the program of the Center will extend to many parts of the world where the potato can be grown and utilized to help solve food problems.

The program of the Center can be broken into three portions. Two of these (A and B) involve the conduction of research, and the third (C) the extension and application of research knowledge in the developing world.

A. The Research Program of the Center is being concentrated around the collection and maintenance of germ plasm and its utilization for some major resistance, quality and production needs in developing countries.

B. Since there already exists a considerable scientific capability to bring about potato improvement within various institutions around the world, the Center is linking to these institutions for specific projects. The basic philosophy is to solve the major potato problems for developing countries in the place where it can be done most rapidly, capably and efficiently. The research approach to solving the major potato problems will include seminars, symposiums and workshops which may be conducted at the Center or ar other locations.

C. The Outreach Program of the Center is concerned with the application of research knowledge and improvement of potato production directly in the developing country. Thus it is concerned with the development of strong national or regional programs and good seed production programs. To help meet these goals the following kinds of training programs will be sponsored:

1. Short courses the duration of which will normally be a potato growing season (planting to harvest);

2. formal education leading to a masters degree at the Center;

3. advanced degree thesis work in which residence and course requirements will be completed at a foreign institution and the thesis work conducted at the Center;

4. post doctorate work - one or two year appointment working with material of the Center before moving along to a national program;

5. visiting scientist - one and two year appointment at the Center for scientists from developing countries to work with the genetic material on a project of particular value to their country. This leads to a permanent linkage between the Center and the scientist and his needs when he returns to his country;

6. in the future, short term visits will be possible for administrators of potato research in developing countries, to help them recognize the potential that the potato may have.

In summary the International Potato Center has a responsibility to catalyze and conduct research for developing countries, and also to promote the application of this research knowledge for potato improvement in these countries. This Symposium has been organized as a part of this catalytic effort.

A committee of Senior Scientists attending this Symposium, and representing several countries, has been named to summarize the discussions of this symposium and make recommendations which can be utilized in the development of the program of the Center. Their report will be published in the proceedings of this symposium.

Please let me or a member of my staff know if there is anything we can do to make your trip to Peru and your participation in the Symposium more enjoyable.

FIRST SESSION

COUNTRY REPORTS ON PROBLEMS AND PROGRESS OF POTATO IMPROVEMENT IN THE UPLAND AND LOWLAND TROPICS

Chairman, Fermín de la Puente
Head, Peruvian Potato Program


NEW

PROGRAMA DE INVESTIGACION DE PAPA EN CHILE

Primo Accatino
Instituto de Investigaciones Agropecuarias, Santiago, Chile

La papa es uno de los principales cultivos y posee un valor económico de 6.5% del valor total del Sector Agrícola.

Es el alimento base de la población chilena y se siembran aproximadamente 80,000 has. anuales con el cultivo siendo el rendimiento promedio de 8.5 a 9.5 ton/has. La disponibilidad per cápita es en promedio de 60 Kgs. al año, la que debe ser elevada a 128 Kgs/año, de acuerdo a la recomendación del Servicio Nacional de Salud. El programa de investigaciones se desarrolla a nivel nacional y pertenece al Instituto de Investigaciones Agropecuarias, siendo su objetivo principal aumentar el rendimiento promedio de la papa.

Los resultados obtenidos hasta la fecha han sido los siguientes:

1. Dada la falta grave de variedades adecuadas, recientemente se han introducido al cultivo nuevas variedades: Desiree, Arka, Spartaan y Ultimus, que superan ampliamente a las ya existentes.

2. Un adecuado programa de semilla de papa Certificada se ha iniciado y que viene a suplir una deficiencia prioritaria para el desarrollo del cultivo. Se espera que para el año 1974 el porcentaje de semilla de papa certificada alcance a la meta de un 25% del total de semilla de papa que se comercializa en el país.

3. La investigación en prácticas culturales está proveyendo información respecto a una relación equilibrada, planta - agua - suelo, rotaciones adecuadas, poblaciones por hectárea y dosis de fertilizantes, prácticas de siembra y control de malezas, enfermedades e insectos.

4. Las pérdidas por almacenaje y conservación deficientes han sido disminuídas apreciablemente mediante el uso de bodegas adecuadas a las necesidades

de conservación de semilla y de papa para consumo. Esta última es conservada, con inhibidor de brote a nivel nacional para suplir los períodos críticos de abastecimiento de Setiembre a Febrero, en la zona central y sur de Chile.

5. Variedad autóctona (Corahila) de gran importancia comercial, ha sido recuperada de total infección virosa, mediante aislación y cultivo de meristemas libres de virus y el material de tubérculos obtenidos está en el programa de certificación.

6. El programa de mejoramiento genético está considerando las prioridades nacionales y cuenta con la posibilidad del uso de nuevo germoplasma y nuevas técnicas en mejoramiento.

7. Se iniciará el programa de investigación en procesamiento y utilización con miras a la producción de harina de papa y papa deshidratada principalmente.

8. El entrenamiento de investigadores y técnicos del programa, ha recibido la valiosa ayuda del Dr. John Niederhauser, quien también presta asesoría Técnica.

PROBLEMAS Y PROGRESOS EN EL MEJORAMIENTO DE PAPA EN COLOMBIA

Edmundo Pérez M., Nelson Estrada y Armando Rodríguez
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El cultivo de la papa ocupa el octavo lugar en importancia en Colombia, con una área sembrada de unas 100,000 hectáreas desde una altura de 1,500 hasta 3,500 m.s.n.m. y una producción de 900,000 toneladas. La mayor parte de esta superficie (80%) está cultivada en extensiones menores de 5 hectáreas, con muy poca mecanización. Es un cultivo básico para los habitantes de tierra fría, en las costas y en otras zonas de clima caliente es reemplazada parcialmente por la yuca y el plátano, pero de todas maneras su uso está bastante generalizado en el país.

La producción abastece las necesidades pero en épocas de cosecha y debido principalmente a fallas en el almacenamiento y en la distribución se presenta abundancia del producto, lo que causa el descenso de los precios al contemplarse una mayor oferta que supera a la demanda. Esto ocasiona un transitorio halago para el consumidor y las consiguientes pérdidas de dinero y entusiasmo para el productor, que se traduce en grandes cambios en cuanto al área sembrada de un año a otro.

En 1948 se iniciaron los trabajos de recolección de las diferentes variedades de Colombia y de otros países y desde esta época se han continuado los estudios de evaluación y mantenimiento de la colección, hibridaciones, prácticas culturales y producción de semilla. En este año (1948) el Gobierno contrató los servicios del Dr. J.G. Hawkes, quien en colaboración con técnicos colombianos elaboraron un plan de trabajo de mejoramiento, de fertilización y de saneamiento de las variedades comerciales más comúnes en esa época.

En 1952 la Fundación Rockefeller dio un impulso muy grande, con presupuesto y ayuda técnica, con lo cual se logró un gran avance en la investigación para lograr mejores variedades, prácticas culturales más apropiadas y la obtención de semilla certificada.

Principales problemas a resolver

Las variedades eran de tipo tardío (6-9 meses), muy susceptibles a Phytophthora infestans, de tubérculos pequeños (menos de 40 grs.) y bajos rendimientos (6 toneladas por hectárea).

El problema más grave que se tiene en la actualidad es el de las enfermedades causadas por los virus, los cuales bajan enormemente los rendimientos. Los más graves en el país son: el enrollamiento de hojas, el virus X, el Y y el enanismo amarillo muy parecido al virus denominado tentativamente Virus 3 en el Perú. Estas endemias son especialmente graves, por la poca información y conocimiento que tiene el agricultor de ellas, caso contrario de lo que ocurre con la enfermedad causada por Phytophthora infestans (Mont.) de Bary a la cual el 90 ó 100% de los cultivadores la conocen y la controlan en forma eficiente.

Otro de los problemas es la presencia de Heterodera rostochiensis (Woll.) en un Departamento papero en el sur del país. Esta plaga recién se detectó hace un año y en la actualidad se están iniciando trabajos de reconocimiento de las áreas infectadas y evaluación de los daños que está causando. Se está estudiando la Colección Central Colombiana con sus 3,000 clones, con el objeto de observar si hay o no alguna variedad o variedades con resistencia a este organismo, y se está trabajando con algunos nematicidas (pero esta solución es muy cara y se espera que otros países que tienen trabajos más avanzados al respecto ayuden a su solución).

La mayoría de las variedades que se cultivan actualmente son relativamente susceptibles a Phytophthora infestans, para cuyo control el agricultor gasta mucho dinero en fumigaciones efectuando en casos severos de ataque hasta 16 aplicaciones.

Son también graves problemas, las heladas y la presencia de Pseudomonas solanacearum E. F. Smith, las cuales serán motivo de una nueva charla en el curso de esta serie de conferencias.

Otros daños son causados por dos hongos que se presentan con menor incidencia: Rhizoctonia solani (Khun) y Rosellinia sp.

En enfermedades bacteriales se puede anotar después de Pseudomonas solanacearum la enfermedad causada por Erwinia atroséptica (Van Hall) Jennison.

En cuanto a prácticas culturales, los principales problemas son: 1) Distancias de siembra muy amplias por parte del agricultor, con sub-utilización del terreno, 2) tamaño de semilla, generalmente muy pequeña (20 a 30 grs.) empleando 2 ó 3 semillas por sitio, 3) empleo de fungicidas poco apropiados, épocas de aplicación y concentraciones inadecuadas, y 4) empleo de insecticidas no recomendados.

Los siguientes insectos son de importancia económica: Chiza (Ancognata-escarabeoides), Tierrero (Agrotis ipsilon), Gusano blanco (Premnotrypes vorax), Pulguillas (Epitrix sp.), Minadores: (Lyriomiza quadrata) y (Gnorimoschema sp.) y Afidos (Myzus persicae). Se han encontrado los insecticidas más apropiados para su control.

Las malezas (de hoja ancha) en muchos casos son agresivas y el control con agroquímicos resulta muy ventajoso. Se han empleado con éxito los Dinitros (Preemerge, Caldón) y también se está usando el Afalón. Entre las malezas más comúnes y abundantes están: Gallinsoa parviflora Cav., G. ciliata (Raf.) Blake, Chenopodium paniculatum Hook, Spergula arvensis L. y Raphanus raphanistrum L.

Para la producción de semilla ha sido necesario establecer un programa de certificación, para demostrar a los agricultores la bondad de la semilla con alta sanidad.

Progresos alcanzados

1. Mejoramiento de variedades: En 1956 se inició la multiplicación de nuevas variedades habiéndose entregado 17 de ellas. Las que más se han distinguido y difundido a los agricultores por sus buenas características son las siguientes:

Diacol-Monserrate: Alta resistencia a Phytophthora infestans, buena calidad, alto peso específico y precocidad (4 1/2 meses).

Diacol-Capiro: Variedad muy precoz de buena calidad del tubérculo (color y forma) y resistente a varias razas de Phytophthora infestans.

ICA-Puracé: Actualmente la más difundida con un 30% de la superficie cultivada en Colombia. Rendimientos altos (20 a 30 toneladas por hectárea) y buena calidad del tubérculo.

ICA-Guantiva: Ha tenido buena aceptación por parte del agricultor. De buena calidad y tolerancia a virus.

ICA-Nevada: Es la variedad más reciente con tolerancia a las heladas (-3°C). Además tolerancia a virus, ligera resistencia a Phytophthora infestans, muy buenos rendimientos (30 toneladas por hectárea), buena forma, color y calidad del tubérculo.

2. Progresos en prácticas culturales: Se han dado recomendaciones especiales en cuanto a distancias de siembra, tamaño de semilla, fungicidas para controlar Phytophthora infestans, épocas de aplicación y dosis más adecuadas, insecticidas para combatir los insectos del suelo y del follaje, matamalezas adecuados y los mejores defoliantes como el arseniato de sodio y dinitros.

3. Producción de semilla: El Programa de Tuberosas, entrega los híbridos más promisorios al Programa de Fitopatología para que se detecte la presencia de virus con inoculaciones en plantas indicadoras y mediante análisis al microscopio electrónico. El material seleccionado se cultiva en zonas altas sobre los 3,000 m.s.n.m. por el sistema de familias clonales con el objeto de tenerlas lo más sanas posibles.

Cuando la producción de estas familias llega a una cantidad más o menos grande se entrega a la Caja de Crédito Agrario para su multiplicación y distribución a los agricultores.

Problemas actuales:

Se consideran como mayores problemas la necesidad de obtener variedades con resistencia a los virus, a las heladas, a la bacteria Pseudomonas solanacearum, al Heterodera rostochiensis y a Phytophthora infestans.

EL PROGRAMA DE PAPA PERUANO

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De acuerdo a las últimas estadísticas disponibles en el país, el cultivo de la papa ocupa el primer lugar de importancia por el valor bruto de su producción y el segundo lugar por su superficie cultivada.

Prácticamente toda la producción es destinada al consumo humano, habiéndose estimado para el año 1969 un consumo de 102 Kg. por persona y por año.

Si bien es cierto, que la oferta interna de este producto satisface la demanda; sin embargo acusa marcados problemas estacionales generados por la transición entre el cultivo de Sierra y Costa.

La recopilación de datos de los últimos 10 años indica que ha habido un incremento de 33% en los rendimientos, con una tasa anual de incremento de 3.4%.

Los principales problemas que limitan la promoción de este cultivo y que son de importancia para esta reunión son:

1) Que aproximadamente en el 80% del área cultivada con papa, se utilizan todavía variedades nativas de baja capacidad de producción, largo período vegetativo y con carencia de resistencia o tolerancia a los principales problemas fitosanitarios y a las condiciones climáticas adversas.

2) Asimismo, que el 96% del área cultivada se encuentra localizada en la región de la Sierra y por lo tanto, constantemente expuesta a las bajas temperaturas o heladas.

3) Y por otro lado, gran porcentaje del área de la sierra se encuentra infestada en mayor o menor grado con el nematode dorado (*Heterodera rostochiensis*).

Cómo problemas de orden regional en el norte de mi país, pero de trascendencia internacional, podría referirme al problema de la "Marchitez Bacteriana" (*Pseudomonas solanacearum*) y al de la "Rancha" (*Phytophthora infestans*).

Hay indudablemente otros problemas, que son más del orden nacional, tales como: carencia de buena semilla, mercadeo, almacenamiento, insumos, etc. que no creo sea de interes tratar con más amplitud en esta reunión.

Con la finalidad de lograr una efectiva investigación, que permita un apoyo positivo a la promoción de este cultivo en el país, se ha formado el Programa Nacional de Papa, el que no es más que la integración y coordinación de las acciones de investigación que se realizan en la E.E.A. La Molina y en las Zonas Agrarias.

Las finalidades de este programa son:

1) Aumentar la productividad de este cultivo;
2) Lograr un eficiente uso de los insumos de la producción;
3) Mejorar la estabilidad de la producción; y,
4) Propender a una mejor calidad del tubérculo.

Los objetivos del programa son:

1) Incrementar los rendimientos unitarios del cultivo;
2) Cubrir la demanda por este producto; y ,
3) Generar un superavit que permita su exportación o procesamiento.

Para cumplir con estos objetivos, se ha planteado la siguiente estrategia:

1) Realizar una investigación en base al desarrollo agropecuario nacional;
2) Lograr una mejor coordinación intra- e inter-institucional;
3) Conseguir una mayor y mejor capacitación y perfeccionamiento del personal; e,
4) Incentivar un mayor intercambio científico a nivel nacional e internacional.

Las acciones de este programa se encuentran concentradas en las diferentes disciplinas: Mejoramiento, fitopatología, nematología, entomología, riegos, suelos-abonos, producción de semilla y extensión. Nuevas líneas de investigación se han considerado en fisiología y en la promoción de los

cultivares "amargos" pertenecientes a las especies S. curtilobum y S. juzepczukii, que vegetan especialmente en la zona Norte y Sur del país.

Para cumplir con las acciones de investigaciones antes referidas, el programa cuenta con los siguientes medios:

1) Personal especializado en cada disciplina, muchos de ellos con estudios de post-grado en los principales centros de investigación en el mundo. Los especialistas coordinan sus acciones con los encargados de las diferentes Zonas Agrarias en las que se ha dividido al país.

2) Laboratorios e invernaderos debidamente equipados en la E.E.A. La Molina y Huancayo.

3) Campos experimentales en La Molina y en las principales áreas paperas del país.

En los últimos años el Programa ha recibido un efectivo apoyo de la Misión de la Universidad de Carolina del Norte y de la Fundación Rockefeller.

Asimismo, el Gobierno a través de la D.G.I.A. nos ha permitido contar con los recursos económicos necesarios para cumplir nuestra labor en la forma más eficiente posible.

Para terminar, quiero solo referir que es el deseo de nuestro grupo peruano y creo de todos los representantes de los países en desarrollo, que este Centro de reciente creación, cumpla en la forma más efectiva su principal objetivo: ayudar a nosotros, los investigadores de los países en desarrollo, a resolver los mayores problemas de producción de este cultivo.

CARACTERISTICAS DEL CULTIVO DE LA PAPA EN MEXICO

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En México, la papa se comenzó a cultivar desde hace 250 años o quizás más en las partes altas de las sierras de la parte central de México. Sin embargo, la época moderna se puede decir que data de 15 años a la fecha. Durante esta época se abrieron nuevas zonas de cultivo, se incorporaron las técnicas más avanzadas, se introdujeron y crearon nuevas variedades, así como también ser formó y se puso en práctica un sistema de producción de semilla certificada.

En los últimos 5 años (1965-1969) hubo un incremento de 42.9% en los rendimientos de papa, sin haberse aumentado la superficie dedicada a la siembra de este tubérculo. Lo anterior ha venido a repercutir en la disponibilidad de mayores alimentos para la Nación, así como la diversificación de la nutrición del pueblo mexicano.

En México se siembran alrededor de 40,000 Has. con un promedio de rendimiento de 12 a 15 tons. métricas por Hectárea; el cultivo se puede efectuar en 21 o quizás más estados de la República. Esto implica necesariamente una serie de condiciones ecológicas diferentes, las cuales representan enfoques de investigación distintos. Sin embargo, el cultivo se puede agrupar dentro de 3 tipos principales:

a) Bajo condiciones de riego. Comprende zonas desde el nivel del mar hasta 2,000 o más metros de altura sobre el mismo, y sembrados con variedades mejoradas (Grupo Tuberosum) de un ciclo vegetativo de 90-120 días de vida y rendimientos de 20-22 tons./Ha.

b) Cultivo en las sierras. El nombre "sierras" implica una extensa zona montañosa de México principalmente de la mesa central, siendo áreas representativas los estados de Puebla, México y

Veracruz. Las variedades que se emplean son "criollas" (del Grupo Andigenum) de ciclo vegetativo bastante largo (190-200 días), sembradas bajo condiciones de Humedad-Temporal, a altitudes que fluctúan de 2,750 a 3,500 m. sobre el nivel del mar y con rendimientos promedios de 5-7 tons./Ha.

c) "Temporal" o época de lluvias. Comprende zonas con alturas de 1,500-2,500 m. sobre el nivel del mar. Se pueden sembrar con variedades resistentes (cruzas de Andigenum - Tuberosum-Demissum) a la enfermedad conocida como Tizón Tardío causada por el hongo Phytophthora infestans (Mont.) de Bary y rendimientos de 10 - 15 tons./Ha. o con variedades susceptibles al mismo pero bajo protección con productos químicos y rendimientos de 18-22 tons./Ha.

A la fecha se reconocen, o cuando menos el autor así lo reconoce, 2 tipos fundamentales de problemas que al ser enfocados y resueltos adecuadamente incrementarían el consumo per cápita de la papa (10-12 Kgs.), el cual actualmente es bajo. Los problemas a investigar son los siguientes:

1. Se debe vigorizar las siembras bajo condiciones de "temporal" o época de lluvias con variedades tolerantes a Phytophthora infestans. Lo anterior implica un estudio para incorporar mayor "calidad" y "adaptación" a las variedades actuales. La siembra de "temporal" con dichas variedades es de un costo más barato y además va dirigida a la clase de escasos recursos económicos que habita la parte central de México, donde puede prosperar el cultivo en la época de lluvias.

2. Parece ser necesario iniciar estudios tendientes a abrir otras zonas con características adecuadas para la producción de semilla de alto registro o fundación, ya que a la fecha sólo se cuenta con una zona que es el Valle de Toluca en el Estado de México. Lo anterior vendría a repercutir en un fortalecimiento de economías regionales de otras áreas y a la vez proporcionar a los productores de papa comercial con diversas fuentes de "semilla" y no exponer la producción a los factores de una sola zona, que por lógica no parece ser muy adecuado.

Hasta Mayo de 1972, el Instituto Nacional de Investigaciones Agrícolas contaba con un Departamento de Papa, el cual operaba con 6 técnicos - 1 Ph. D., 3 M.S. y 2 B.S. o Ingeniero Agrónomo -, este personal es-

tablecía regularmente 40-50 experimentos en 9-10 diferentes localidades de la República y evaluaba un total de 20,000 clones bajo las 3 condiciones ecológicas que se tienen en México. Los problemas que requerían de uso de Invernadero y/o Laboratorio se atendían en las Oficinas Centrales de Chapingo, Méx. El autor tenía dividido el programa en las siguientes áreas de investigación: 1) Mejoramiento; 2) Fitopatología; 3) Producción de "semilla"; 4) Calidad; 5) Divulgación Técnica y 6) Diversos.

A partir de Junio se decidió que desapareciera o no existiera un Departamento de Papa. Las investigaciones sobre mejoramiento serán efectuadas en el Departamento de Horticultura y las de patología en el de Fitopatología.

Sin embargo nosotros pensamos-y con esto terminamos la presentación- que los altos incrementos de rendimiento obtenidos en los últimos años indican que la intervención de la papa en la dieta mexicana ha ido aumentando notablemente y sugieren una intensificación de la investigación para el mejor y mayor aprovechamiento de la disponibilidad de este alimento.

DEVELOPMENT OF THE POTATO IN KENYA

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Introduction

The cultivated potato, Solanum tuberosum originated from the South American highlands of Peru, Bolivia and probably Colombia from diploid wild types with 2n = 24 chromosomes (Burton, 1948; Dodds, 1965; Hawkes, 1967; Simmonds, 1969 and 1971). Later there evolved both diploid and autotetraploid cultivars with the latter being commercially the most important Andean group.

According to Simmonds (1971) few potatoes from the Andigena group botanically known as Solanum andigena, were taken to Spain, but they were poorly adapted to the temperate climate. The sixteenth century introductions were only a small fraction of the Andean germplasm but in the eighteenth century through breeding some promising cultivars adapted to the temperate climates emerged. These quickly diffused over the European continent and the potato became established as one of the major food crops in Europe.

History of the potato in Kenya

"The English Potato" as commonly known in East Africa was introduced into Kenya from Europe (undoubtedly from England) by the early European settlers; but there is no record of what particular year or by whom. However, the annual reports of the Ministry of Agriculture (1912, 1917) state that the earliest recorded potato importation into Kenya took place in January 1912 followed by further importation of seed potatoes from South Africa in 1917. The Agriculture Ministry (1929) reported that the imported stocks deteriorated after three years or six growing seasons due to virus diseases and healthy potato tubers had to be imported regularly.

Distribution of potato cultivation and climatic conditions

Potatoes are grown between 4,500 ft. 1371 m.) and 9,000 ft. (2742 m.), elevation and between latitudes 2°N and 2°S of the Equator on both sides of the Rift Valley with a yearly rainfall ranging between 30 and 60 inches (762-1524 mm.). There are two planting seasons in the Eastern side of the Rift. The "long rains" crop, is planted in March and lifted in July, and the "short rains" crop is planted in October/November and lifted in February. The rainfall during the short rains is rather erratic, hence the crop is very light. The rains are heavier and more evenly distributed on the Western side of the Rift Valley where there is only one planting season in April/May with lifting in August/September. The mean temperature is normally between 60°F and 65°F and potatoes can grow all the year round when rainfall is adequate.

The best elevation for potato growing is between 6,000 ft. (1828 m.) and 8,500 ft. (2590 m) which is mainly in the settlement schemes and the small-scale farming areas where the average size of holding is between 2 to 18 hectares and 0.5 to 8.0 hectares, respectively. In Kenya, potatoes are produced both as a food and as a cash crop and some farmers are becoming more and more specialized in potato growing both for seed and ware markets. The present potato acreage, estimated to be about 60,000 hectares, is small when compared with the other food crops; but there has been remarkable improvement in cultural practices and in disease and pest control; hence yields of 10-12 tons per acre have been reported. According to the F.A.O. (1955) reports, the average acreage for potatoes between the years 1948-1952 was about 5,058.7 hectares (12,500 acres) with approximately 4.1 tons per hectare (1.68 tons per acre). The annual potato consumption was also estimated to be about 9 Kg. (20 lbs.) per person. Today the potato is in greater demand and it is now a common practice for many town people to plant a few rows of potatoes in their backyards.

During the last three years, there was a serious maize shortage due to drought and, because maize is the staple food of many Kenyans, the Ministry of Agriculture felt there was a need for developing the potato industry. During this period a bag of potatoes could cost as much as eighty (80) Kenya shillings. Due to its high calorie production potential per acre per given amount of water the potato was given high priority in our Agriculture. Simmonds (1971) reported that, nutritionally the potato has a potential similar to any other tropical root crop. But if we accept the fact that in Kenya we can grow two crops of potatoes per year, in contrast to one crop of yam or cassava per year, then the obvious choice would be potatoes.

Unfortunately, there are still many potatoes interplanted with other crops in Kenya and the yield is very low (Table 1).

TABLE 1. Comparative surface planted to potatoes and other temporary starchy crops in hectares (x 1,000) on small scale farms and settlements schemes.

Temporary crops	Short rains 1969/70			Long rains 1970		
	Single	Mixed	Total	Single	Mixed	Total
English potato	6.4	14.5	20.9	6.4	15.3	21.7
Sweet potato	6.1	16.5	22.7	4.6	25.0	29.6
Cassava	21.3	54.6	77.7	13.8	77.1	90.9
Yams	0.2	16.0	16.2	0.7	11.4	12.1

Problems of potato development in Kenya

Kenya is not unique in regard to some of the problems experienced in an attempt to develop potato varieties. In 1968, it was realized that the potato varieties which were developed in and for the temperate countries were only good for one or two seasons in Kenya. Secondly, the main potato diseases in Kenya are late blight (Phytophthora infestans), Bacterial wilt (Pseudomonas solanacearum), leaf roll and viruses e.g. Y, X, and S. Therefore, an inter-disciplinary potato unit was established in Kenya to produce commercial varieties suitable for East African growing conditions. This work is progressing well but the following areas of research require to be explored.

1. In Kenya, potatoes are grown between 8,500 ft. (2590 m.) and 9,000 ft. (2742 m.) mainly in Kinangop, Molo, around Mt. Kenya, Mau Narok and Dundori; but unfortunately in these areas, potatoes are often damaged by frost. It has been shown by Brown (1963) that about half of the arable land in Kenya with 35" (949 mm.) rainfall or more, (approximately 10,500 sq. miles) grows no crop properly other than potatoes. This land which is presently vacant or under-utilized would accommodate approximately 600,000 ten-acre farms (allowing 72,000 acres of roads, schools and recreational centres) and would support up to 6,000,000 people provided an alternative food crop to maize is found. The potato, being quick-growing constitutes such a crop subject to disease and frost-resistant types being developed.

2. Extension service - The present extension service in Kenya is far from being adequate, and it is not uncommon to find farmers who know very little about potato cultivation e.g. time to plant, spacing, fertilizer application rates and use of fungicides. Moreover, experience has shown that the poor farmers are the ones who have serious trouble with bacterial wilt, late blight viruses and a host of other problems.

3. Storage and marketing of ware potatoes - Although Kenya can produce clean, good quality seed throughout the year in different ecological zones, it has been difficult to take advantage of this because of the following:

   (a) Potatoes are very bulky and it is difficult to transport them from the remote areas to the marketing centres, and prices of such potatoes are too high to compete favourably with locally produced potatoes.

   (b) In some seasons drought may affect the planted crop causing the price of potatoes to fluctuate from twenty Kenya shillings, at the time of lifting, to fifty Kenya shillings per 80 Kg. bag after only two to three months. Therefore, investigation to establish the proper storage conditions should be undertaken urgently.

   (c) There is no proper marketing organization in the country to buy potatoes on wholesale and no credit facilities for the would-be buyers. Furthermore, there are no processing factories.

<u>Minor diseases and pests</u>

(a) Root knot nematodes (<u>Meloidogyne</u> spp.)

(b) Potato tuber moth (<u>Phthorimea</u> <u>operculella</u>)

(c) Cutworms (<u>Agratis</u> spp.)

(d) Mealy bugs (<u>Pseudococcus</u> spp.)

(e) Blackleg (<u>Pectobacterium</u> <u>phytophthora</u>)

(f) Black scurf (<u>Rhizoctonia</u> <u>solani</u>)

(g) Target spot (<u>Alternaria</u> <u>solani</u>)

Potato research project

The Kenyan Research Section was officially started on July 1, 1970 with the development of facilities at the National Agricultural Laboratories, as the disease intensive centre for breeding and raising seedlings, screening for disease resistance and initial selection for commercial quality, and at Mthanga Farm as the disease-free centre for the multiplication of healthy stocks of any promising cultivars produced.

The staff consists of 14 Scientific Officers and 1 Farm Manager. There are ten small research glasshouses and one large glasshouse for the screening of seedlings at both N.A.L. and Mthanga Farm. In addition, the borehole and the dam (4.5 million gallons) to facilitate irrigation at the two centres are now in operation.

The research objective is to produce potato varieties specially adapted to Kenya's ecological conditions. Such varieties should be outstanding in yield, size, shape, quality and disease resistance and should provide a range of maturity types.

Breeding for disease resistance

In East Africa, Blight and bacterial wilt are the two most important diseases. Both diseases were first reported in Kenya in 1941 and 1945 respectively (Nattrass, 1944-1945). The blight is an air-borne disease that is reported to have spread quickly across the African continent, dramatically destroying all potato crops. Wilt is both seed and soil borne and once the field is contaminated it takes years before any potato crop can be successfully grown again. Therefore, a comprehensive breeding programme to produce high yielding varieties with a high degree of resistance to Blight, some resistance to Wilt, and resistance to viruses was started at N.A.L. in 1971. Tuber samples of about 160 selections for trial and breeding purposes have been imported. Some 500 packets of hybrid seed have been introduced from the Scottish Plant Breeding Station, and also some 30 packets from Colombia, which are being screened for disease resistance.

Bacteriology

Large numbers of seedlings are being screened for wilt resistance. Another objective is to establish the ecological areas and limits above which wilt is not serious. Pathogens are being tested with a view of establishing the best inoculation technique and in addition, studies on the biology of the pathogen are in progress.

Virology

In Kenya potato viruses A, S, X,Y, and leaf roll are present. The common aphis are Myzus persicae, Macrosiphum euphorbiae, Aulacorthum solani and Aphis gossypii and a survey is being conducted to determine their importance in the spread of PVY and leaf roll. Isolates of viruses A, S, X, Y, and leaf roll are being maintained for testing new varieties from the breeding programme for their reaction to these viruses.

Clonal maintenance and rapid multiplication

The maintenance of the current commercial varieties in disease-free condition and the rapid multiplication of new varieties using the green stem cutting technique are conducted at Mthanga Farm. Presently approximately 5 tons of a new seedling NF/66 has been produced.

Training of seed inspectors

A course has been started to familiarize seed inspectors with the commercial varieties, diseases and inspection standards required to produce certified crops. In May/June 1972 16 students attended this course on "Potato Variety Identification and Diseases". Of these, five came from Uganda and one from Tanzania and they all passed the test with credit and received a certificate of merit.

Protein programme

This programme was started in July, 1971 by a graduate student at the Faculty of Agriculture, Nairobi. The main objective is to determine the heritability of protein content and then breed for higher protein levels in potatoes. Other objectives will involve determining the influence of altitude, fertilizers, and moisture on protein content. Screening for protein content among our clones is now in progress.

Drought resistance

Materials imported from Colombia and U.S.A., which were bred for drought resistance are currently being bulked at the National Agricultural Laboratories and as soon as sufficient stocks become available, yield trials will be conducted in the medium potential areas in Kenya. Although it is too early to judge, many of these seedlings produced good tubers during the short rains in Kenya and, astonishingly, none of these hybrids were affected by blight to any appreciable level.

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THE POTATO AS A SUBSISTENCE AND CASH CROP IN UGANDA

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The potato, Solanum tuberosum (L.) is known in Uganda as the "Irish" or "English" potato to distinguish it from the "Sweet" potato, Ipomoea batatas (L.) Lam. It was introduced into Uganda at an unknown date presumably during the last twenty years of the nineteenth century by colonial administrators or missionaries. It is reported by Tothill (10) that by the year 1900 the potato was already grown in Uganda largely for sale to Europeans.

Tothill (10) also reports that there were several subsequent introductions mostly from Kenya by Government officials and individual travellers. It can also be assumed that there were introductions from Zaire and Rwanda since there was free movement of both Europeans and Africans between these countries and Uganda especially into the district of Kigezi. Thus by 1940 the potato was already grown in the highlands of Kigezi, Toro and the slopes of Mount Elgon in Sebei, and it was already being used as a subsistence crop in those areas. In 1947, the Government introduced new seed from Kenya to expand production in the highland areas (3).

Potato cultivation in Uganda has now expanded to such a level that there are well over 7,000 hectares (6) and half of this area is situated in the highland district of Kigezi as is shown in Table 1. Table 1 also shows that the potato has spread to some lowland areas notably Buganda, Bunyoro and Ankole. Nevertheless in spite of the relatively large expansion in potato growing during the last 70 years, the potato is a very minor crop in Uganda compared with the traditional non-cereal carbohydrate staples such as plantains, sweet potatoes and cassava as Table 1 clearly shows and as observed by Mc Master (5).

TABLE 1. Area occupied by Irish potatoes and some traditional staples in Uganda.

District	Irish potatoes	Sweet potatoes	Plantains	Cassava
Buganda	223	20,235	211,253	36,018.
Toro	202	*	*	*
Bunyoro	162	4,856	12,545	9,713
Ankole	81	4,047	52,206	1,619
West Nile/Madi	202	2,024	1,619	40,065
Bugisu/Sebei	2,024	3,642	40,875	3,238
Kigezi	4,047	23,068	11,332	**
Others	101	275,196	134,360	78,917
Total	7,042	333,068	464,190	169,570

* Data not available.
** Very little grown.

Source: Produce Marketing Board for Irish Potatoes and Uganda Census of Agriculture Vol. III 1966, for the other crops.

It should also be noted that the area suitable for potato cultivation is less than 10 per cent of the total arable area in Uganda because it is a high altitude crop. This fact would tend to limit its value as subsistence crop on a national level but would in theory increase its potential as a cash crop in the lowland areas where it would be relatively scarce.

The potato as a subsistence crop

In order to appreciate the present and future positions of the potato in the subsistence economy of Uganda vis-a-vis the other traditional carbo-hydrate staples and especially the non-cereals, it is important to identify the characteristics of an ideal subsistence crop for Ugandan farmers. Most farmers

in Uganda practice an unscientific and uncapitalized form of Agriculture. They do not use fertilizers, nor pesticides nor fungicides and they have a restricted labour force usually confined to members of the family. Therefore an ideal subsistence crop must be able to give satisfactory yields in spite of weed competition and pest and disease attack. It should have good storage properties and must, of course, be of acceptable palatability. It must also be of good dietetic properties since rural people have a monotonous diet. The traditional Ugandan non-cereal carbohydrate staples, while not perfect subsistence crops, go a long way towards satisfying the criteria mentioned above. For example the sweet potatoes' vegetative growth is relatively fast covering the ground and thereby excluding most weeds. Although it may be severely attacked in some seasons by the butterfly Acraea acerate Hew., it is relatively free from devastating diseases and pests. The sweet potato keeps very well in the ground for several months and gives relatively good yields without the use of fertilizers (4). It can also be grown from an altitude of 900 to 1800 meters.

The Irish potato on the other hand does not grow well in lowlands because none of the varieties which have so far been introduced in Uganda is adapted to the lowland areas. The yields are poor (11) both in the highlands and lowlands because it is generally severely attacked by both early and late blight. Therefore it would seem that it will be necessary to develop varieties adapted not only to the highlands as Wurster (11) observed, but also to the lowlands before the potato can become a universal subsistence crop in Uganda.

It should also be noted that there are already several carbohydrate staples adapted to lowland areas. Thus, whereas in Kigezi, where most of the Irish potatoes are grown, the sweet potato is the only major competing staple, there are many such crops in lowland areas e.g. plantains, cassava, finger millet (mijo) and sweet potatoes. These crops could act as a dis-incentive in the adoption of the Irish potato as a subsistence crop. Further, Irish potatoes, unlike sweet potatoes, plantains or cassava, require more weeding and have to be harvested at one time and would therefore require the creation of storage space which is always limited in a small holding because crops such as grain legumes and cereals also compete for storage space.

The potato as a cash crop

The Irish potato, unlike plantains, cassava and sweet potatoes can after harvests, be stored for long periods under Uganda conditions and is easy to package and to transport. These characteristics make it an important crop for sale to large urban communities which are situated far away from the present centres of production in the highlands. That there is a market for

Irish potatoes in Uganda is shown by the relatively large imports of potatoes from Kenya and Tanzania during the last 10 years shown in Fig. 1. These imports though fluctuating, have involved sometimes over thirty thousand quintals valued at over one million shillings (7.2 shillings = 1 US dollar) between 1965 and 1967 and in 1971, and came mainly from Kenya.

The potatoes sold in urban areas are also obtainable from internal centres especially from Kigezi. The marketing of potatoes in Kigezi is handled by the Kigezi Vegetable Union. Between 1963 and 1968 the potatoes handled by the Union increased five times from about 45,000 to 230,000 Kg.(7) which indicates that the farmers have been obtaining good revenue from the sale of potatoes.

Potatoes are however very expensive as shown in Table 2. They are very often twice as expensive as sweet potatoes or plantains and on a dry weight basis would be more expensive than finger millet (1).

Acceptability of the potato as a food in Uganda

The success of the potato as a subsistence and cash crop will depend on whether or not it possesses and acceptable taste. The older generations in Uganda have very little taste for Irish potatoes but there appears to be strong evidence that the potato is a popular food among the youth.

A questionnaire on the palatability of the Irish potato compared with another eight common foodstuffs was sent to six boarding high schools in the vicinity of Kampala and was answered by 300 students brought up in rural areas. Of these, 124 students were from Buganda, 85 from the Western Region, 50 from the Eastern Region, 41 from the Northern Region and 78 were women. The analysis of the questionnaire is shown in Table 3. On a national level, the Irish potato was third in popularity after sweet potatoes and matooke, a dish prepared from plantains, and was followed by rice, cassava, finger millet, yams, maize meal and sorghum, in decreasing order of preference. In Buganda, the potato ranked second after matooke. In the Western Region potatoes ranked third, in the Eastern fourth and in the North fifth. In Kigezi, the most important potato growing district, the potatoes ranked second after sweet potatoes and women preferred them to all other foods except matooke. These results show that the potato may be one of the most preferred foods in Uganda.

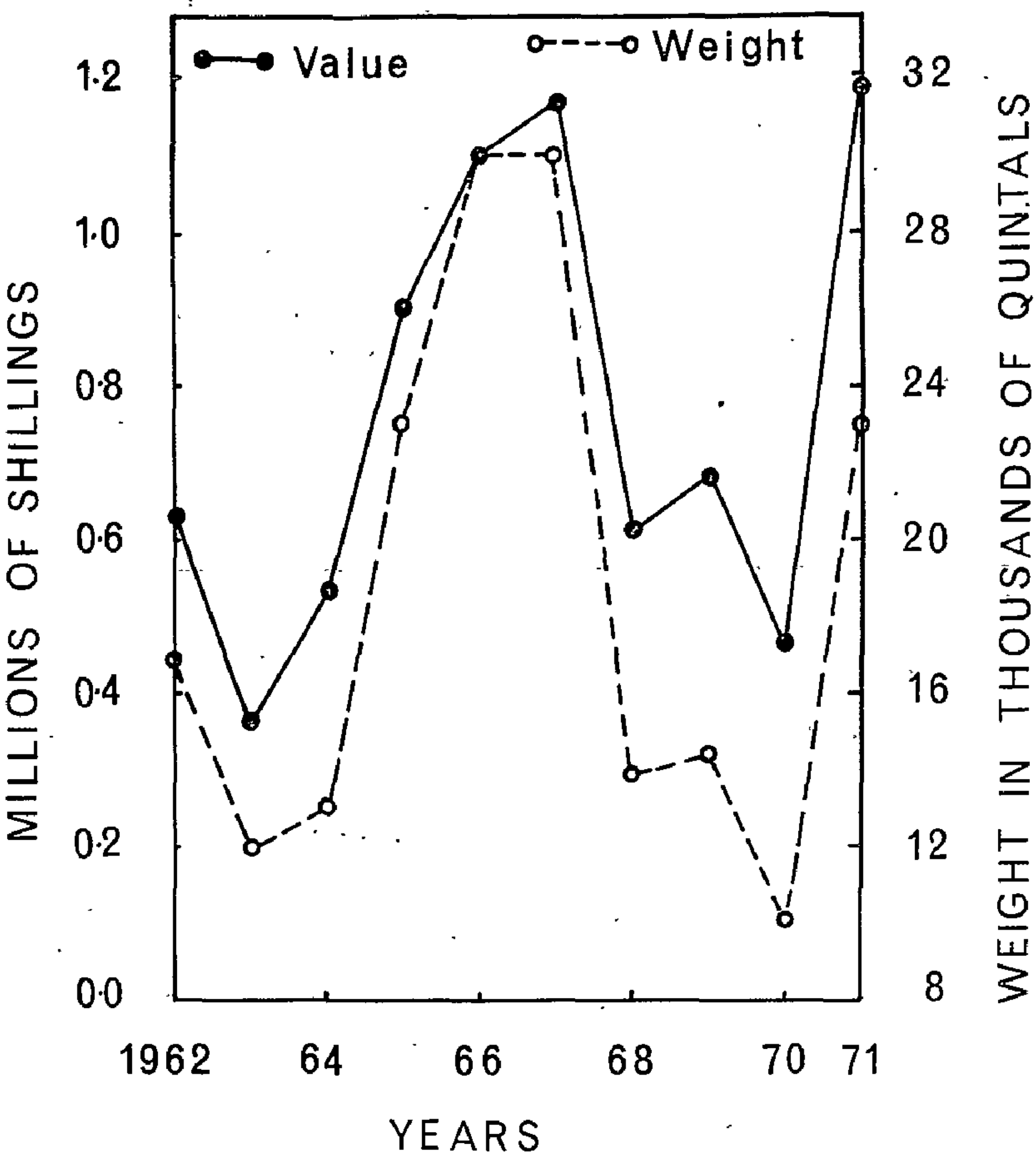

FIGURE 1. IMPORTS OF IRISH POTATOES INTO UGANDA FROM KENYA AND TANZANIA. (SOURCE: ANNUAL TRADE REPORTS; EAST AFRICAN CUSTOMS AND EXCISE DEPARTMENT).

TABLE 2. Local Market prices for Irish potatoes, sweet potatoes and plantains in 1971.

Place	Cents per kilogram		
	Irish potatoes	Sweet potatoes	Plantains
Kampala	92	87	48
Arua	138	54	-
Kabale	39	28	34
Jinja	77	39	30
Mbarara	46	33	23

Source: Annual assessment of prices for Agricultural produce in Uganda 1971: Produce Marketing Board.

TABLE 3. The acceptability of Irish potatoes and certain other Ugandan staples among high school students.

Food	National	Buganda	Eastern	Western	Northern	Kigezi	Women
Irish potato	3	2	4	3	5	2	2
Sweet potato	1	3	2	1	2	1	4
Matooke*	2	1	1	2	9	3	1
Cassava	5	5	6	6	3	6	5
Yams	7	6	7	7	8	8	6
Rice	4	4	3	5	4	4	3
Finger Millet	6	8	5	4	1	5	7
Sorghum	9	9	9	9	6	7	9
Maize Meal	8	7	8	8	7	9	8

* Dish prepared from plantains.

Food value of Irish potatoes in Uganda

One of the most important public health problems in Uganda is protein malnutrition.. There is particularly an acute shortage of sulphur containing amino acids especially methionine and cystine (8). Hence a good subsistence crop should contain sufficient levels of these essential amino acids.

The Irish potatoes grown in Europe and America apparently contain reasonable amounts of methionine (2). But, unfortunately current research, in the Faculty of Agriculture Makerere University, seems to indicate that the Irish potatoes grown in Uganda are not only very low in protein, but also their protein quality is poor with regard to sulphur containing amino acids (9). Therefore it could be argued that future work on the improvement of the potato should take into account improving upon the amount and quality of the protein. But it seems debatable whether or not much energy should be expanded in trying to convert a food which is basically a source of carbohydrates into a source of protein. There appear to be strong arguments in favour of improving upon the protein in crops which already contain large amounts of protein such as the grain legumes.

Conclusion

The foregoing account indicates that although Irish potatoes are a minor crop in Uganda as a whole, they are commonly grown as a subsistence and cash crop especially in the highlands. Together with sweet potatoes and plantains the potato may be one of the most popular carbohydrate foods in Uganda, but is very expensive. There appears to be a need for developing varieties which are better adapted both to the highlands and lowland areas in order to make the potato play a bigger role in the subsistence economy of rural people and to make it cheaper for the urban communities.

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POTATO GROWING AND ITS PROBLEMS IN KOREA

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Since the potato was introduced into Korea from India and China in 1824, it has been widely cultivated and has served as a staple food for the peasantry living in the mountainous areas. From the latter half on the 1930's, it has been extended to use in side-dishes and as raw material for starch processing. It has also become possible to grow potatoes on the paddy field prior to rice transplanting. Consequently, the potato cultivation area has been gradually enlarged.

The situation of potato growing with respect to area under cultivation, yield, and total production from 1962 to 1970 is shown in Table 1. The varieties that are cultivated at the present time, their maturity characteristics, origin, and percentage of area in each, are shown in Table 2.

TABLE 1.- Area, yield and production of potatoes in Korea (1962-1970).

Year	Area (Ha.)	Yield (Kg/10^a)	Total production (M/t)
1962	48.900	843	412.300
1963	45.860	852	390.900
1964	47.150	1.210	570.900
1965	60.700	957	580.490
1966	60.940	1.130	688.250
1967	58.570	967	566.070
1968	60.600	1.018	617.000
1969	56.460	1.061	599.290
1970	53.970	1.121	605.150

TABLE 2.- Principal information about varieties being cultivated at present.

Name of variety	Maturity	Country of origin	Percent area in cultivation
Irish cobbler	early	U.S.A.	80%
Local variety	Midseason and late	Korea	10%
Shimabara	For double-cropping	Japan	5%
Others			5%

Seed potato producing entities

A. The Research Station has as its ultimate objective the production of Breeder's Stock of improved varieties. The characteristics of this Station and its programmes are as follows:

The Alpine Research Station, Office of Rural Development, is located at Whoengke ri, Doam-myon, Pyongchang county, Kangwon Province (Taikwanryong pass) at an altitude of 820 m. It has an area of 100 Ha. and 9 staff members.

The main research programmes are:

a) Potato Breeding trials;

b) Potato virus disease trials;

c) Potato disease and pest trials;

d) Experiment of cultural practices;

e) Nutrition and physiology of potato;

f) Production of breeder's stock.

B. Potato foundation-stock farms: one in each Kangwon and Kyongki Provinces.

C. Certified potato seed farms: each of the 9 Provinces has one farm.

Potato research in Korea

A. Breeding programme - Local varieties have long been grown in the Northern part of Korea. In 1920, the Nankok variety, introduced from Germany, was cultivated in Nankok farm in Kangwon province and about the same year, Irish cobbler variety was introduced from Hokaido, Japan and has been widely cultivated throughout Korea.

From 1945 to 1962, a number of new varieties including Irish cobbler were introduced from the U.S.A. Once agencies for the production of seed potatoes were established in 1962, production of seed potatoes and its distribution began in earnest.

The area of potato cultivation has been gradually increasing since potatoes have been shown to grow successfully on paddy fields before rice transplanting.

A breeding programme was established in 1965 in order to find varieties suitable for the Korean climate. The contents of the programme has changed from the selection of introduced varieties to cross breeding, so that we are conducting crossing trials between varieties and trying to introduce prominent genes of wild species for the development of superior varieties which are early maturing, high yielding, disease resistant and high in starch content. From 1965 to 1971, 98 cross combinations have been made and superior varieties will soon be selected based on yield potential and other characteristics.

B. The objectives of breeding - Priority has been given to varieties which are early maturing, high yielding, disease-resistant and with a high starch content. Also, attempts are being made to develop potato varieties for potato chipping and the processing of starch.

C. Selection of varieties - Selection of varieties suitable for Korean climate and conditions is done by an examination of introduced varieties. Those which have been selected and distributed until now are: Irish cobbler, Kennebec, Warba, Saco (introduced from U.S.A.), Shimabara and Tachibana (introduced from Japan).

D. Cross breeding - Selection of superior varieties, especially disease-resistant varieties, is under way among 98 cross combinations by inter-varietal and inter-specific hybridization. Emphasis is also placed on the use of

genes in wild species, for breeding of superior and disease-resistant varieties.

E. Control of diseases:

1. Research on virus diseases: The major viruses such as PVX, PVY and PLRV have been separated and identified through the reaction of indicator host plants by sap inoculation or insect transmission, physico-chemical examination, antiserum reaction and morphological examination with an electron microscope. The obtention of PVX-free stock is being accomplished through antiserum reaction and tissue culture methods. Separation and identification of strains of PVY is being done through the mechanism of transmission by insects, reaction of host plants to sap inoculation, and serological tests. PLRV research includes studies of insect transmission and establishment of chemical control methods.

2. Research on late blight: For the development of varieties resistant to late blight, the races of Phytophthora infestans prevailing in Korea have been determined. They are races 0, 1, 1.3, 1.4, 2.3.4, 3.4, 1.3.4 and 1.2.3.4, the most frequent of which are races 0 and 3.

3. Ring rot disease control: Ring rot disease was a big problem in 1965, but came under complete control after 3 years through the sterilization of the cutting knife and other appliances, and renovation of infected seed potatoes. Use of the Gram Staining Method was quite effective in determining the presence of this bacterium, Corynebacterium sepedonicum.

F. Control of pests:

1. Control of aphids: Virus-carrying aphids have been investigated in terms of their classification, distribution and ecology, and chemical control. The following virus-carrying aphids have been determined:

   a) Myzus persicae

   b) Aulacorthum solani

   c) Aphis gossypii

   d) Lipapis erysimi

2. Control of soil pests: A research programme has been conducted into the ecology and methods of control of pests in the soil (cut worm, army worm, and wire worm).

G. Cultural practice trials:

1. Investigation of yield-increasing factors.
2. Determination of optimum sowing times.
3. Establishment of early-planting cultural practices.
4. Double cropping practices.

H. Herbicide trials:

1. Herbicidal effect on grasses and broad-leaved weeds.
2. Investigation of chemicals and their optimum concentration.
3. Investigation of effective period of herbicide application.

Principal problems

A. Breeding of varieties which are early maturing and resistant to low temperature: In the North of central Korea, severe winter cold keeps barley from growing successfully and also, the period of optimum temperature (average above 8° C) for potato cultivation lasts only 50 days from early April until June 10 which is the rice-transplanting period. So, for successful potato cultivation in this area it is necessary to germinate the seeds and cultivate them under vinyl covers during the early part of the potato growing season. Therefore, it is desirable to develop new varieties which are faster in tuber setting and more vigorous under low temperature at the early growing stage, than the Irish cobbler variety which is being cultivated.

B. Production and supply of disease-free seed potatoes at a low cost: The production cost of virus-free seed potatoes is at present too great to be fully utilized by farmers. A new production method must be developed in order to grow virus-free seed potatoes successfully in warm areas such as the southern part of Korea. Production costs would then be immensely reduced, making it thus possible for every farmer to purchase disease-free seed potatoes.

C. Breeding of varieties resistant to diseases and rich in starch: The development of new varieties which are rich in starch (more than 20%) and resistant to virus diseases is greatly needed because seed potatoes have degenerated to a great degree owing to aphid transmission of viruses.

Technical Co-operation

A strong and intimate relationship and co-operation between Korea and the International Potato Centre and as is the case with the International Rice Research Institute in the Philippines should be developed as soon as possible to accomplish the following objectives:

A. Exchange information of research on potatoes.

B. Training of Korean specialists at the Centre, to improve their techniques.

PROBLEMS AND PROGRESS OF POTATO IMPROVEMENT IN INDIA

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Although cereals constitute the staple food of the masses in India, the potato has also gained wide acceptance as an important article of food by the rich and the poor alike. In fact, it is the highest common factor of all the popular vegetable preparations used in the country. The crop is grown, to a greater or lesser extent, in almost all the States of India. Its cultivation is more concentrated in the Northern plains in the sub-tropical zone than in the warmer Southern parts in the tropical zone. The crop is grown in summer under relatively long day conditions, in the Northern hills; in spring, in Northern midhills, low hills and North Western plains; in autumn or winter under shorter day conditions in the plains; in winter as well as the rainy season in plateau areas; and in summer, autumn as well as winter in the Southern hills. The crop is mostly rainfed in the hills and is almost wholly irrigated in the plains and valleys.

The area, production, average yield and per capita consumption of potato have almost doubled over the last two decades (Table 1). Admittedly the per capita consumption of 6.8 Kg./annum is low as compared with 200 Kg. or more in some of the advanced countries. The yield of about 90 q/Ha is also low, partly because the duration of the early crops is only about 70 days and of the main or the late crops about 90 to 130 days in the plains and the plateau areas which account for nearly 90 per cent of the area under potatoes in India.

Problems of potato improvement

The problems which have limited the area, production and consumption of potatoes in the country are:

1) Ecological restraints in certain parts;

TABLE 1. Area, production and average yield of potatoes and per capita consumption in India.

Year	Area (000 hectares)	Production (000 tonnes)	Avg. Yield (Q/ha.)	Per capita consumption Kg/annum
1949-50	234	1,543	65.9	
1950-51	240	1,660	69.2	3.65
1951-52	250	1,712	68.5	
1952-53	255	1,992	78.1	
1953-54	257	1,956	76.1	
1954-55	266	1,764	66.3	
1955-56	280	1,859	66.4	
1956-57	286	1,724	60.3	
1957-58	321	2,004	62.4	
1958-59	338	2,348	69.5	
1959-60	362	2,733	75.5	
1960-61	375	2,719	72.5	5.96
1961-62	365	2,447	67.0	
1962-63	413	3,365	81.5	
1963-64	415	2,593	62.5	
1964-65	429	3,605	83.9	
1965-66	480	4,060	84.5	
1966-67	473	3,522	74.4	
1967-68	501	4,232	84.4	
1968-69	537	4,773	88.9	
1969-70	496	3,913	78.9	
1970-71	514	4,640	90.3	6.76

Source: Estimates of Area and Production of principal crops in India issued by Directorate of Economics and Statistics, Ministry of Agriculture, New Delhi.

2) disease and pest incidence;

3) the problem of supply of high quality healthy seed potatoes of varieties suited to different agroclimatic conditions;

4) storage and dormancy problems;

5) low inputs and standards of cultivations adopted by many of the growers; and,

6) utilization problems relating to storage, marketing, transport and processing.

Ecological restraints: The ecological conditions in the different potato growing areas are given in Table 2. High temperatures affect the early crops in the initial stages of plant development, and the main crops and the late crops in the later stages of development in the plains. Warmer conditions prevail in the rainy and the winter seasons in the plateau areas. Frost hazards forbid early planting in spring both in the hills and North-Western plains. Thus unfavourable temperatures reduce the length of the growing season and consequently the crop yield. Warmer temperature conditions limit the spread of the crop to new areas and its intensity in the cropping pattern in existing areas. Moisture deficiency particularly on coarse textured soils affects the rain fed crops in the early stages, and excess moisture in the late stages in the hills. Soil fertility affects the crop yield in the hills and plateau areas. Fine-textured soils pose management problems in certain areas.

Disease and pest problems: Late blight occurs every year in a severe form in all hills and periodically in the plains (Table 2). The main races of the fungus are 0, 1 and 4. Besides late blight, brown rot and root-knot nematodes occur mainly in mid hills and low hills. Brown rot is also present in the plateau region. Wart has established in Darjceling hills. Charcoal rot causes considerable losses in the late liftings in the plains. Except in the very high hills, spread of viral diseases is high in all areas. Tuber moth and mites are important pests in the plateau areas. Cyst forming nematode has posed a serious problem in the Nilgiri hills.

Seed problem: Aphid and leaf hopper vectors undermine the health standards of seed stocks, particularly in the plains, mid hills and plateau areas, during certain periods of the year with a consequently high incidence of virus diseases. Information on the areas and seasons most suitable for

production of virus free seed was lacking in the past, and supply of good quality seed from a reliable source acted as a limiting factor.

The choice of varieties was also limited in the past. In the hills and plateau areas, some of the foreign introductions established themselves. Among these, mention may be made of Up-to-Date and Magnum Bonum in Himachal Pradesh; Arran Consul, Arran Banner and Kerr's Pink in the Eastern hills; Great Scot in Nilgiri hills; and Up-to-Date in the peninsular plateau. In the plains, local varieties such as Phulwa, Darjeeling Red Round, Satha and Gola the identity of which is not traceable, came to be grown predominantly. These cultivars have certain shortcomings. For example, all the commercial varieties grown in the hills and the plains are susceptible to late blight and brown rot. The varieties such as Phulwa and Satha produce small sized tubers. Darjeeling Red Round and Gola degenerate rapidly.

Storage and dormancy: In the plains, potato have to be stored over hot summer months. Cold storage of potatoes has come up gradually during the last three decades. Previously, table potatoes were stored in ordinary potato houses at high temperatures (25°C to 30°C) for three months or so after lifting. Seed potatoes had to be stored for 7 to 8 months, i.e., till the next planting. The losses caused by rottage, sprouting and shrinkage were high. The storage problem apparently led to the selection of varieties such as Phulwa, producing small-sized tubers with good keeping quality and long dormancy. To minimise storage losses, as far as possible, the seed crops were planted late in winter and in spring. Moreover, delayed plantings in the plains were necessitated in the case of hill seed of varieties such as Darjeeling Red Round and Up-to-Date, lifted in autumn, so that the seed became non-dormant before planting. The practice was, however, not sound, as such late crops were exposed to high aphid incidence in spring and were, therefore, liable to rapid degeneration. With the development of cold storage facilities in the country, the storage problem has become less serious. Nearly 1/3rd of the potato crop of the country is now being kept in cold stores at about 2°C (36°F to 38°F temperature). There is need for more cold stores. However, cold storage of potatoes is not an unmixed blessing; leaf roll virus which is inactivated at high temperature storage, remains viable in the stores, as indicated later. The production of virus-free seed potatoes in large quantities has thus assumed even greater significance now than ever before.

In the hills, potatoes are stored in winter and storage problems are more or less the same as occur in cold countries.

TABLE 2. Ecological conditions and disease and pest problems in the

Region	Elevation m. above sea level & soil type	Crop season and whether Irrigated or Rainfed
I. Himalayan very high hills	2500-3000 m., acid or acidic soil of varying texture & depth.	Summer: April to Sept. (Rainfed)
	3000-3500 m., acidic soils of coarse to loamy texture.	Summer: June to Sept. (Irrigated)
II. High Himalayan hills	1800-2500 m., acid or acidic soil of coarse to loamy texture.	Summer: March to Aug-Sept. (Rainfed)
III. Himalayan Mid-hills	1000-1800 m., acidic soil of varying texture	Spring: Jan. - Feb. to May-June (Irrigated)
		Autumn: Aug-Sept. to Nov. (Irrigated)
IV. North-western plains	Below 300 m., deep alluvial soil of neutral to slightly alkaline reaction.	Autumn: Sept-Oct. to Dec.-Jan. (Irrigated)
		Spring: Dec.-Jan. to April-May (Irrigated)
V. North-central plains	Below 300 m., deep alluvial soil of neutral to slightly alkaline reaction.	Early: Sept. to Nov.-December. (Irrigated)

different regions of India.

Climatic features	Diseases*	Pests*
Frost and hails in early stages. Excess moisture during tuber development phase.	Late blight	White grubs, epilachna beetle, slug, leaf-hoppers, cutworms.
Frost in early stages, dry weather during growth period, early snow-fall near harvest season.	Late blight occasionally in later stages.	
Frost and hails after planting, deficient moisture in early stages of growth, excess moisture during and after tuberisation.	Late blight during tuber development period, marginal flavescence purple top-roll, Wart in Darjeeling area.	Lepidopterous larvae, cutworms, white grubs, epilachna beetle, leaf-hoppers, aphids in May-June.
Frost and hails after planting.	Early blight, brown rot, high incidence of viral diseases.	Cutworms, root-knot nematodes.
Frost before lifting.	Late blight in early stages, high incidence of viral diseases.	-do-
Supra-optimal temperatures in initial stages, frost in later stages.	Early blight.	Leaf-hoppers(Jassids)
Supra-optimal temperatures during tuberisation.	Late blight, early blight, charcoal rot, black-scurf	Aphids, cutworms, lepidopterous larvae.
Supra-optimal temperatures throughout, rain showers after planting causing gappy stands.	Early blight, and other leaf spot diseases.	Jassids.

TABLE 2. (continued)

Region	Elevation m. above sea level & soil type	Crop season and whether Irrigated or Rainfed
		Main: Oct. - Nov. to Feb.-March (Irrigated)
		Late: End Nov.-Dec. to March. (Irrigated)
VI. (a) North-eastern	Deep alluvial soils of slightly acidic to slightly alkaline reaction.	Winter: Nov. to March
(b) Central Indian plains	Light sandy to heavy soils of slightly alkaline reaction.	- do - (Irrigated)
VII. Low hills & plateau region	600-1000 m., red sandy and fine-textured black soils.	Winter: Nov. to Feb.-March (Irrigated)
		Rainy: July-August to Sept.-Oct. (Rainfed)
VIII. Southern hills	1000-2000 m., acid soils of varying texture.	Summer: March - April to Aug.-Sept. (Rainfed)
		Autumn: Aug.-Sept. to Dec.-Jan. (Rainfed)
		Winter: Jan.-Feb. to May (Irrigated)

* Underlining indicates severe disease or pest problem.

Climatic features	Diseases*	Pests*
Long growing season. Frost in submontane areas.	Late blight, black-scurf charcoal-rot in later liftings.	Epilachna beetle, aphids in later plantings.
Short growing season, supra optimal temperatures in later stages.	Late blight, Charcoal rot, early blight.	Epilachna beetle, cutworms and aphids in later stages.
Short and mild winter.	Late blight.	Epilachna beetle, aphids, red ants in Assam.
-do-	-do-	
Short and mild winter.	Early blight, brown rot.	Cutworms, tuber-moth, aphids.
Warm rainy season with indifferent soil moisture conditions.	Sclerotium rot, wet & dry tuber rots, purple top roll; witch's broom.	Cutworms, tuber-moth, aphids & mites.
Moisture deficiency in early stages.	Late blight Brown rot	cyst forming nematodes.
Frost in later stages	Late blight, brown rot and viral diseases.	cyst-forming nematodes and aphids
[illegible]	Late blight, brown rot and viral diseases.	cyst-forming nematodes and aphids.

Low-inputs and standards of cultivation: Most farmers use farmyard manure, oil cake and nitrogenous fertilizers. Phosphatic and potassic fertilizers and plant protection measures are used by progressive growers mainly. Many farmers still use small-sized potatoes as seed. In some of the areas, potatoes are grown on the same fields in successional cropping. This has aggravated the pest and diseases problems, as in the Nilgiri hills.

Utilization problem: Despite low over-all production vis-a-vis the requirements of the country, temporary gluts often occur near harvest time in the plains resulting in a price crash, and adversely affecting the economics of the crop.

Most of the foregoing problems are being tackled. There is a great scope for improving the place of the potato in Indian agriculture, if the results of researches are translated into cultivator's practice, and outstanding problems are solved through further research and development.

The National Potato Programme: Recognition of the potentialities of the potato crop in the context of food problem in India and the need for long range comprehensive research on the diverse problems of this crop, led to the establishment of the Central Potato Research Institute in 1949 with a view to stepping up potato production in India. The Institute is carrying out research, on a country-wide basis, on all aspects of potato improvement, development of agronomic technology, study and control of diseases and pests, seed production, storage and control of dormancy. Over the years the Institute has developed a strong national programme which is continually being strengthened in the successive Five Year National Plans. Besides the main Station at Simla, the Institute has its regional potato trial -cum- experimental centres/research stations, to carry out research on the regional problems of the potato. These centres/stations are located at Kufri-Fagu (H.P.), Mukteswar (U.P.), Darjeeling (West Bengal), Shillong (Meghalaya) and Ootacamund (Tamil Nadu) in the hills; at Jullundur (Punjab), Babugarh (U.P.) and Patna (Bihar) in the North Indian plains; and at Rajgurunagar near Poona (Maharashira) in the plateau area. The research activities of the Institute which were hitherto carried out in the different sections representing different disciplines have since been reorganized into four Divisions, viz., 1) Genetics including potato breeding and plant physiology, 2) Crop and Soil Sciences including Agronomy, Soil Science, Biochemistry and Agricultural Engineering, 3) Plant Pathology including fungal, bacterial and viral pathology and 4) Entomology including nematology.

The Institute has fairly well-equipped laboratories, glasshouses, stores and field facilities at Simla and Kufri-Fagu. Basic field and laboratory facilities have also been created at the regional centres/stations, and the facilities are being further augmented. The Institute and its associated centres/stations are manned by qualified and experienced staff consisting of 20 Ph. D's 63 with master's degree, 8 graduate assistants and 63 supporting technical staff.

Recently an all India Coordinated Potato Improvement Project has come into operation. In this project the Central Potato Research Institute with its regional centres/stations and the Agricultural Universities/Colleges or Research Stations of the State Departments of Agriculture, collaborate to implement the following programme of work:

1) Breeding and selection of improved potato varieties suited to different regions;

   a) Early varieties resistant to the golden nematode for the Nilgiris;
   b) short-duration, day-neutral varieties suitable for <u>Rabi</u> crop, as well as monsoon crop, in the hills and plateau areas of Peninsular and Central India;
   c) late blight resistant and drought-resistant varieties for Eastern hill region;
   d) rapid-bulking varieties for areas of short and mild winters in the plains of West Bengal, Orissa, Madhya Pradesh and Gujarat, for fitting them into multiple cropping systems;
   e) varieties suitable for processing and industrial use for areas of high production potential, as in U.P.

2) Research on the cultural and fertilizer requirements of improved varieties of potatoes in the different regions for the production of seed and ware potatoes.

3) Study of the plant development under varying agroclimatic conditions.

4) Cropping patterns in relation to potato, and their economics.

5) Survey of pests and diseases affecting potatoes in the field and stores in the different regions, and evolving methods of controlling them.

6) Survey for the build-up of aphid populations in potato crop in the principal growing regions in the country, to locate areas suitable for producing disease-free stocks.

The Institute functions under the control of the Indian Council of Agricultural Research, and is primarily concerned with research. Potato development is the responsibility of the Departments of Agriculture in the States. Potato development officers have been appointed by the Department of Agriculture in the important potato-growing States. The Institute, however, imparts training to the staff concerned with potato development, by organizing short-term courses both in the hills and plains every year.

The National Seed Corporation and the State Departments of Agriculture produce Foundation seed with the Breeder's seed supplied to them by the Institute. The programme of seed production is co-ordinated by the Department of Agriculture, Union Ministry of Agriculture.

Progress made sor far:

1. Varietal improvement: A number of improved potato varieties have been bred, and released as the "Kufri series", a name derived from the station where they have been bred and are maintained in disease-free condition. Among the released varieties, mention may be made of

   a) Kufri Sindhuri and, Kufri Chamatkar as main crop varieties suitable for areas of long winter in the North-Central plains,

   b) Kufri Chandramukhi and Kufri Alankar as short-duration varieties suitable for fitting in the relay cropping system in the North Indian plains, and also for general cultivation in areas of short and mild winter,

   c) Kufri Sheetman as a frost resistant variety for cultivation in the North-Eastern plains region and

   d) late blight resistant varieties, namely Kufri Jeevan and Kufri Jyoti for cultivation in the North-Western hills, Kufri Khasigaro and Kufri Naveen for the North-Eastern hills, and Kufri Muthu for the Southern hills. Two promising wart-immune selections, namely, F. 5242 and F. 3977 have also been developed for cultivation in Darjeeling hills where both late blight and wart pose serious problems.

2. Seed production:

   a) The development of the "Seed Plot Technique" which now makes it possible to produce disease-free seed stocks of potatoes in the North

Indian plains in autumn (October to December) when aphid incidence is low, is one of the major contributions of the Institute. It has revolutionized the practice of seed production. Formerly the seed crop was raised in the plains, using the hill seed, in the late autumn or spring, when aphid infestation is high. This practice undermined the health standards of seed stocks resulting in low yields.

b) Promising results have been obtained in controlling vectors of virus diseases with the use of systemic insecticides. This has opened up possibilities of raising seed crops in less suitable areas such as Peninsular India, thus necessitating replacement of seed in only smaller quantities each year, for multiplication locally.

c) The techniques of breaking dormancy, whereby freshly-harvested dormant tubers can be treated with chemicals for planting the next crop immediately, has been developed and successfully applied. Apart from being useful for growing successional crops with local seed in the same year in certain areas, this makes possible the effective use of selected healthy hill-units for planting in the plains under "seed plot technique" in autumn.

3. Control of diseases:

a) The effectiveness of fungicides and the economics of their use for the control of late blight has been studied. The racial distribution of Phytophthora infestans has also been studied. Race "O" is the most common and races "1" and "4" occur in some areas.

b) Leaf roll virus could be inactivated by high temperature storage (30°C or so) in ordinary stores or by hot water treatment at 53°-55°C for 17 to 25 minutes.

c) Seed treatment with Agallol coupled with hot weather cultivation has been found to greatly minimize the damage from black-scurf, which is both tuber-borne and soil borne. In recent studies, seed treatment with acetic acid has given promising results.

4. Control of insect pests, vectors and nematodes:

a) Treatment with heptachlor controlled cutworms which particularly affect the late or the spring crop. Malathion has been found to be

beneficial in the control of tubermoth, which is a serious pest of potato in Maharashtra. The damage from vectors could be minimized through the use of insecticides, as stated above. Studies have also been completed with a number of systemic and contact organophosphate insecticides available on the Indian market with a view to preparing a schedule for the control of insect pests and vectors using organophosphate insecticides instead of organochlorines. Progress has also been made in the field of determination of residues of commonly used insecticides in potato tubers and on the control of potato tubermoth by the sterile males release technique. Population dynamics of aphid vectors of potato viruses in important potato growing regions in the country is being studied for growing seed potatoes by adopting the seed plot technique.

b) A leaf rooting technique has been developed for screening genetic material for resistance to root-knot nematode. Potato hybrids H.C. 115, S. vernii and S. spegazzinii have shown marked resistance to the root-knot nematodes Meloidogyne incognita, an important pest of the potato in the mid hills. They are being utilized in the programme for breeding resistance to this nematode.

5. Agronomic investigations:

a) Response to fertilizers was shown to depend on variety, planting time and moisture supply. Exotic and improved varieties with rapid bulking habit and large sized tubers showed higher response to potassium than the local varieties. Optimum planting time gave best response to nitrogen. Frequent irrigations improved response to nitrogen.

b) Fertilizer schedules have been prepared on the basis of experiments conducted so far.

c) At high temperature in ordinary stores, small sized tubers, from early lifted crops and varieties with long dormancy, kept better than large tubers, from delayed liftings and varieties with short dormancy.

d) Treatment with IPPC inhibited sprouting at temperatures of about 15 to 18°C, but not at higher temperatures in country stores.

e) Seed crops can be earthed up finally, immediately after planting and weeds controlled with pre-emergence treatment with simazine and/or post emergence treatment with 3,4-DPA, to minimize spread

of mechanically transmitted viruses such as 'X' and 'S', by eliminating post-planting cultivation operations.

6. Breeder's seed production: A scheme for the production of Breeder's seed has been taken up at the Institute as advance action under the Fourth Five Year Plan. Under this scheme, the seed of improved varieties and important commercial varieties is developed in four stages starting with tuber-indexing, at Kufri-Fagu (Himachal Pradesh) in the high hills, and at Jullundur (Punjab) and Daurala (U.P.) in the plains. The available facilities at Patna and Babugarh centres and Mukteswar station are also being utilized for the purpose. The seed is made available to the State Departments of Agriculture/National Seeds Corporation for further multiplication as foundation seed. Annually about 6,000 quintals of seed is supplied to the collaborating agencies. This quantity on further multiplication is expected to cover about 1/6th of the present area under potatoes in the country. As the programme develops, larger quantities of Breeder's seed will become available to feed the seed production programmes in the States to bring about complete coverage of potato area with quality seed eventually.

Important research projects in progress:

1. Breeding for resistance to late blight: Work on breeding varieties resistant to late blight was intensified as of 1961. This programme is being carried out in collaboration with the Scottish Plant Breeding Station and the International Potato Improvement Programme of the Rockefeller Foundation in Mexico. The major objective of the project is to develop varieties possessing field resistance to late blight. During the period 1961 to 1970, about 263,000 seedlings resulting from 166 cross combinations were screened for their reaction to a mixture of the prevalent races (0, 1 and 4) of the pathogen. 8,000 seedlings were selected and exposed to infection under field conditions. The genotypes showing high degree of field resistance were sent to Mexico. On the basis of the data on field resistance, the genotypes were selected for release as commercial varieties. Kufri Jyoti, Kufri Jeevan, Kufri Khasigaro, Kufri Naveen and Kufri Muthee have been released for cultivation as stated earlier. A number of promising hybrids are on the assembly line. The released varieties have maintained their attribute of late-blight resistance, and are in great demand. These varieties will now gradually replace old susceptible varieties in the areas where late blight is a serious problem. As these varieties remain green for a longer period, they have not only a higher yield potential but are exposed to infection particularly

with the "yellows" group of diseases. Consequently, a strong seed programme is necessitated so that the solution of one problem does not lead to the creeping in of another.

2. Breeding for resistance to brown rot: Under a PL-480 project, a large collection of indigenous as well as exotic varieties along with wild species and material sent by Dr. Rowe is being screened against the brown rot bacterium at Bhowali (U.P.). So far only two clones of S. phureja have shown complete freedom (high degree of resistance) from wilt in the field as well as tuber rot in storage. These are B.H. 34 (derived from E.C. 97045) and S.S. 74-6-3. These two clones will be crossed with a few polyhaploids as well as treated with colchicine for the production of tetraploids to be used in crosses with tuberosum. Since 1969, a total number of over 6,000 accessions have been tested.

3. Resistance to nematodes: The leaf rooting technique developed at the Institute has been used for screening varieties, clones and wild species for reaction to root-knot nematode. In the project for breeding against the cyst forming nematode which occurs in Nilgiri hills, two hybrids have been found to possess a high degree of resistance. However, in view of the complex nature of the organism with a number of biotypes, this project will have to be strengthened for diversified broad-based resistance against this nematode. A number of poly-haploids have also shown varying degrees of resistance. It seems that the cyst forming nematode in Nilgiris is different from that in European countries; varieties reported as resistant abroad are found to be susceptible.

4. Poly-haploidy: Under a PL-480 scheme, polyhaploids of selected varieties have been developed. These together with the polyhaploids received from the U.S.A., are being screened for their potentialities for breeding and even for direct introduction as a commercial variety. Selected polyhaploids have been treated with colchicine for the induction of tetraploids with a view to deriving desirable commercial types.

5. Breeding for Charcoal rot resistance: In the PL-480 project for breeding varieties resistant to charcoal rot caused by Macrophomina phaseoli, over 8,000 cultivars/hybrids have been tested using the tooth-pick method developed at the Institute. Immune reaction in clone CRH-15-33 of S. chacoense has been found against all the biotypes collected so far. Some tuberosum hybrids like H.C. 294 have also shown complete immunity to all the biotypes isolated. These are being utilized in the breeding programme for the incorporation of resistance into commercial varieties.

6. Adaptation of potato to warmer regions of India: This project will be reviewed in another session of this symposium.

7. Varietal resistance to major viruses: Genetic stocks are screened by the Division of Plant Pathology for their reaction to important viruses. In the breeding programme an important objective is to select genotypes with in-built resistance to mechanically transmitted viruses such as 'X' and 'S'.

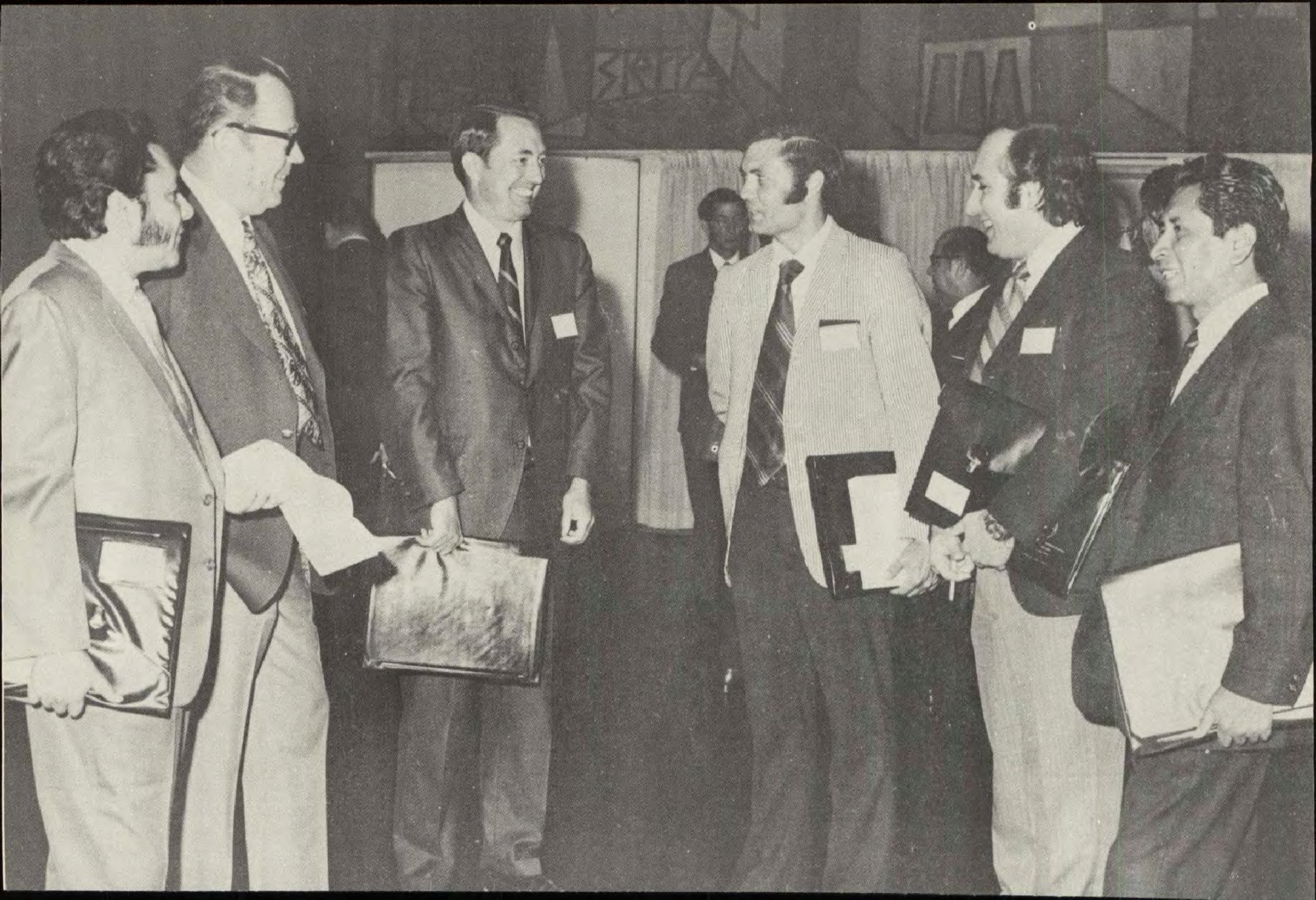
8. Pathological investigations: Symptoms of leaf hopper transmitted diseases such as "marginal flavescence" and related diseases like purple top roll and witches broom, are noticed in the field both in the hills and plains, and the hairy sprout symptom is seen in storage. It is apprehended that these diseases which are suspected to be associated with mycoplasma like organisms, may assume serious proportions in the future. Work on these is in progress departmentally as a follow up of the work initiated earlier under a PL-480 project on hairy sprout disease.

Also under way are studies on the development of agronomic technology for improved varieties; reaction of varieties to dormancy-breaking chemicals; chemical control of weeds; long-term direct, residual and cummulative effects of phosphate and potassic fertilizers; growth regulation with chemicals; assessment of quality of potatoes and exploiting the possibility of sun-drying of potatoes with a view to utilizing the solar energy for obtaining a cheap non-perishable product.

SECOND SESSION

POTATO GERM PLASM BANKS

Chairman, Jorge León
Chief of Crop Ecology and Genetic
Resources, FAO-Rome



THE IR-1 POTATO COLLECTION

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The potential value of Solanum germ plasm is well recognized by potato breeders. As a result, much effort has gone into collecting, maintaining, and evaluating the wild and cultivated Solanum species. However, much more work is required. First, we need to obtain a more adequate sample of germ plasm. Research on the proper procedures for maintaining these stocks is needed. And finally, there should be a much greater effort to evaluate the germ plasm pool that is already available and to learn how to best utilize the diversity that exists.

My primary assignment for today is to discuss the potato germ plasm collection that is in Sturgeon Bay, Wisconsin. In addition to this, I want to offer some suggestions on some specific things that I think should be done in the area of potato germ plasm maintenance in the future.

The title of the project to maintain potato germ plasm for the United States is the Inter-Regional Potato Introduction Project. It is called inter-regional because it is supported by funds from all of the states in the four Experiment Station Regions in the United States. It was the first inter-regional project that was developed and so it is also known as IR-1.

The need for a Solanum germ plasm center in the United States was recognized soon after the first potato collecting expeditions went to South America. Many stocks were being introduced but most of the materials were being lost because there was no facility available to maintain these diverse species. As a result of the efforts of potato breeders in the United States, a project was developed and initiated at Sturgeon Bay in 1950.

The objectives of the project are to introduce, maintain, classify, distribute and evaluate potato germ plasm. I want to discuss the IR-1 Project

under each of these objectives.

Stocks are added to the IR-1 collection largely by: 1) direct requests to foreign laboratories or stations for certain of their breeding selections and 2) organized expeditions led by plant collectors. Over 3500 introductions have been received from approximately 40 countries since 1950. Samples of almost 90 species are now in the collection. These stocks have been introduced through the cooperation of many potato workers from all over the world.

Maintenance of the stocks in a large collection is a task that requires care and planning. Maintenance by vegetative reproduction is costly and requires constant attention to prevent virus infection from spreading. For this reason, those clones that have a known genotype that is of value are maintained vegetatively. This includes tester stocks such as late blight differentials and cultivars from other countries. In the near future, genetic marker stocks may be added to the collection.

Over 90% of the introductions are maintained as true seed that is obtained through self-pollinating, sib-mating, or hybridization. After the seed is extracted, it is dried to 5% moisture, counted and sealed in metalized polyester packets. When treated in this manner and stored in a refrigerator, seed stays viable for 10-15 years.

When a germ plasm collection sends out a sample of any of its stocks, it is important that the material be correctly labelled. In most cases, the scientist that receives the stocks will not be aware of all of the details of Solanum taxonomy and may not recognize an improperly identified stock. It is essential then that all stocks in a collection be checked by a taxonomist and that accurate records be maintained. The stocks in the IR-1 Collection are checked by taxonomists such as Hawkes, Corell, Ochoa, and Ugent. Stocks that are not clearly identified normally are not included in the inventory of available introductions.

Distribution is possibly the most important function of a germ plasm collection. It does no good to accumulate a large collection if the stocks are not used. Distribution requires a certain amount of effort by the collection to publish information about its stocks and to promptly supply material that is needed. First, an inventory of stocks that are available is needed. This must be provided to all potential users. In the inventories that are distributed from Sturgeon Bay, screening data are compiled so that scientists will have a basis

for selecting stocks for their research. A germ plasm collection needs to be organized to respond quickly and with accuracy to any request. Records of all shipments should be kept on file. A special effort is needed to anticipate future needs and to determine new procedures that might assist the scientists and promote more use of the material. For example, many scientists prefer to plant tubers rather than seed. For this reason, the IR-1 Project has a program to produce tuber families of wild species each fall. These are distributed each spring with the understanding that these clones will not be asexually propagated at Sturgeon Bay.

Distribution of IR-1 stocks now averages well over 3000 lots of seeds and tubers each year. These are sent to approximately 20 states in the United States and to approximately 20 other countries. I feel that this has been one of the most successful aspects of the IR-1 Project.

Distribution of stocks and utilization are closely related. As the number of stocks distributed each year has increased, the number of publications that report the use of IR-1 stocks in research has increased as well so that now it is over 30 per year. A broad research effort is required in order to gain information on the value of the Solanum species and the best procedures for utilizing these traits.

The use of IR-1 stocks over the past 4 years is shown in Table 1. Most stocks have gone to breeding programs and for evaluation for horticultural type and for screening for resistance to disease and insects. Distribution during this period averaged almost 3500 stocks per year.

This has been a relatively brief summary of the organization and work of the IR-1 Project. Now I want to make some comments on the problems that should receive attention in the future. With the development of more active germ plasm collections in South America, the question is often raised about the emphasis that these collections should have and how the IR-1 Project might relate to these new collections.

I presented some data in 1970 on the number of accessions that were being maintained by three of the largest collections in the Northern Hemisphere. At that time, it appeared that there were only 1500 different accessions of the wild species. Over half of these were for 7 species and over half of the species were represented by from 1 to 4 accessions. This points up the fact that more collections of many of the lesser known species are badly needed.

TABLE 1.- Use of IR-1 stocks that were distributed 1968-71.

Use	Numbers
Breeding programs	3204
Horticultural evaluation	2590
Entomology	1956
Pathology	1787
Genetic	1497
Taxonomy	1008
Nematology	751
Physiology	577
Germ plasm centers	474
Teaching and exhibits	59
Gardens, ornamental	20
Total	13,923

Here is where the collections in South America can make a tremendous contribution. Because of their location, they are in a position to repeatedly sample areas, send teams into more remote areas, and generally accumulate a larger sample of the diversity that is available. These stocks can be shared with other collections to ensure that they will not be lost. A good example of this is the extensive collecting that has been done recently by Dr. Okada and Mr. Hoffman in Argentina. In the past two years they have sent over 300 new accessions of species from Argentina to the IR-1 Collection. Efforts such as these will ensure that there will be a large sample of diversity available for potato scientists to utilize.

Another serious problem that concerns many people is the question of how to preserve the complex of cultivated forms. I do not believe that it is possible to maintain and evaluate every clone. Even if the cultivars that are synonyms and that are different could be distinguished I do not think an attempt should be made to preserve all of these as clones. If the assumption that these stocks are valuable because they represent a genetic resource and that they will not be used in their current form as cultivars is correct, then it seems logical that these stocks should be put into systematic genetic pools that can be maintained efficiently. The most realistic approach seems to be to group together cultivars on a basis of geographic origin, and then intermate them to form populations that can be maintained in the form of seed. These gene pools could then be sampled and evaluated. Here again, scientists in South America are probably in the best position to evaluate this problem and to implement maintenance procedures.

Although almost all of the wild species can be maintained easily at Sturgeon Bay, a few species are extremely difficult to propagate. It may be easier to have species such as these grown in collections closer to their native habitat. Research should be done with these species to determine their requirements for reproduction. Such information may eventually prove to have wider application.

The wild Solanum species represent a natural resource that must be maintained. The organization of germ plasm collections in South America during the past few years is a significant development. There are many ways in which these collections and the IR-1 Project can continue to cooperate in the future. I hope that the discussions during this symposium will do much to advance this mutual effort.

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EL GERMOPLASMA DE PAPA EN SUDAMERICA

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Cerca de medio siglo después de que apareciera publicada la primera referencia sobre la existencia de la papa (45) el botánico suizo Gaspar Bauhin en 1596 (2), presentó al mundo científico la primera descripción botánica de esta planta designándola Solanum tuberosum, nombre conservado por Linneo en su obra Species Plantarum (44) y que se mantiene hasta el presente para la papa cultivada.

El conocimiento de las papas silvestres permaneció, sin embargo, ignorado por más de tres siglos después de descubierta la América. Su existencia es revelada muy brevemente, por primera vez, por Ludovico Bertonio (4) y no por Cobo (24) como generalmente se afirma, cuando en su Vocabulario de la Lengua Aymara, publicado en el Perú en 1612 cita el nombre de "Apharu" con el que se conoce actualmente a una papa silvestre que abunda en el Altiplano y que Bitter (5) describió a principios del presente siglo, bajo el nombre de Solanum acaule.

Sin embargo, fue el explorador francés Philibert Commerson quien en 1767 colectó por primera vez una papa silvestre con fines científicos. Esta papa recogida en las vecindades de Montevideo, Uruguay, fue también la primera especie silvestre presentada al mundo por Dunal en 1813 bajo el nombre de S. commersoni (cit. p. Hawkes y Hjerting, 40). Desde entonces hasta el presente se han propuesto gran número de especies para la Sección Tuberarium del Género Solanum, grupo confinado al continente Americano dentro del cual Sud América tiene gran riqueza como luego veremos.

Al revisar la enorme masa de descripciones de especies tuberíferas propuestas desde la época de Dunal hasta hoy, podremos constatar cerca de 340 entidades sin contar las especies dudosas (nomen dubium y nomen nudum). No obstante, a la luz de los conocimientos actuales esta cifra se reduce grandemente. Después de referirnos brevemente a los trabajos taxonómicos realizados por Dunal (29,30,31), Torrey (62), Schelechtendal (60,61), Lindley (43),

Gray (34), Baker (1), Berthault (3), Bitter (5,6), Wittmack (67), Rydberg (59), Juzepczuk (41, 42), Bukasov (12,13,14,15,16,17,18), Hawkes (35,36,38), Hawkes y Hjerting (40), Correll (25), así como a las contribuciones aportadas por autores residentes en Sud América, tales como Philippi (58), Vargas (64, 65, 66), Cárdenas (20,21,22,23) y otros, llegamos a la segunda mitad del presente siglo en la que aparecen nuevas contribuciones. La década de 1960 hasta el presente, constituye un período particularmente importante para el mejor conocimiento del germoplasma americano de papas y su clasificación. Así en 1962, aparece la primera obra monográfica y la más completa conocida hasta hoy sobre la materia escrita por el Dr. Donovan S. Correll bajo el título "The potato and its wild relatives" (26). Un año después de la publicación de esta obra, el Profesor Hawkes (38) nos da a conocer su segunda revisión sobre los Solanum tuberíferos. También en 1962 se publica el primer trabajo monográfico sobre las papas silvestres del Perú (Ochoa, 48), este mismo año Montaldo y Sanz (47) dan a conocer su clasificación sobre las papas silvestres y cultivadas de Chile. En 1966 Flores Crespo (32), informa sobre los resultados de su revisión del grupo tuberífero silvestre de México. Finalmente en los últimos diez años se han dado a conocer un buen número de especies silvestres nuevas debidas principalmente a las contribuciones de Brucher (7,8, 9, 10) y Ochoa (49,50,51,52,53,54,55,56,57).

Correll y Hawkes, en las obras ya referidas (26 y 38) dan una amplia información sobre la sinonimia de especies que orienta hacia una mejor comprensión del problema hasta entonces caótico. Sin embargo, entre ambos investigadores existen desacuerdos de clasificación particularmente en lo relacionado con los grupos taxonómicos o series. Así, mientras que para Correll existen 26 series, Hawkes basa sus clasificaciones sobre un total de solamente 17. A esta situación se suma la última publicación monográfica hecha por los investigadores rusos (Bukasov et al. 12) aparecida recientemente en Leningrado, en la cual el número de series consideradas es 32 y donde muchas especies que obviamente son sinónimas se mantienen todavía como válidas.

Basadas en los trabajos de los autores hasta aquí mencionados y en nuestras propias observaciones de campo, laboratorio e invernadero, realizados principalmente en los últimos diez años, creemos que el número total de especies tuberíferas silvestres, sin considerar las hibriodógenas, llega escasamente a cerca de unas 140 (11,15,28,33,37,38,39,40,46,63), de las cuales 27 están distribuídas en Norte y Centro América comprendidas en un total de 8 series: Conicibaccata, Bulbocastana, Demissa, Longipedicellata, Morelliformia, Pinnatissecta, Polyadenia y Trifida. Las otras 112 especies se encuentran en Sud América agrupadas en un total de 12 series: Acaulia, Circaefolia, Conicibaccata, Commersoniana, Cuneolata, Etuberosa, Ingaefolia, Juglandifolia,

Megistacroloba, Olmosiana, Piurana y Tuberosa:

Dado el tema que nos ocupa, presentamos a continuación en la forma más resumida que nos ha sido posible, la actual existencia del germoplasma sudamericano. De este modo, vemos en el Cuadro 1 la existencia del número total de especies silvestres (endémicas y nó endémicas) y series por países. Aquí puede apreciarse fácilmente que el germoplasma de los Solanum tuberíferos silvestres de Centro y Norte América es pobre comparada con el de Sud América. Así, en México donde existe la mayor concentración con un total que estimamos de 27 especies, es también el único país donde se han encontrado hasta hoy especies endémicas que alcanzan a 17, las otras 10 restantes se encuentran distribuídas principalmente entre Guatemala y Estados Unidos de Norte América. Aunque otros autores consideran la presencia de S. juglandifolium en Costa Rica, no nos ha sido posible comprobar este hecho ya que la única colección atribuída a Oersted a mediados del siglo pasado, no tiene indicación de localidad definida. De este modo, Costa Rica, tendría solamente una especie tuberífera, S. oxycarpum, encontrada también en México y Panamá.

Contrariamente, el número de papas silvestres sudamericanas es casi cuatro veces mayor al existente en Centro y Norte América, encontrándose la mayor concentración en el Perú que cuenta con un total de 61 especies de las 112 consignadas para Sud América. Este elevado número, es más impresionante aún, si además se considera que hemos reducido a sinónimos cerca de 40 especies peruanas. La riqueza del material genético existente en el Perú puede apreciarse mejor en el mismo Cuadro 1 si se compara por ejemplo con Bolivia, país que le sigue al Perú en importancia numérica en Sud América. Así, mientras que en Bolivia de un total de 23 especies hay solamente 8 endémicas, en el Perú se encuentran 55 endémicas y 6 no endémicas.

En el Cuadro 2 se dá la relación de los grupos taxonómicos o series de las especies silvestres sudamericanas y su distribución geográfica. Aquí, puede observarse que la única serie común para todo el Continente resulta Conicibaccata, representada por S. oxycarpum con 2n=48 cromosomas.

En los Cuadros 3, 4 y 5 hemos consignado la totalidad de especies endémicas que consideramos al presente existentes en cada país. Además, se anota para cada especie su número cromosómico al estado diploide, dato este último que en varios casos se da a conocer por primera vez. Del mismo modo, habiendo especies cuya distribución geográfica abarca más de un país, en el Cuadro 6 hemos consignado la lista de especies no endémicas.

CUADRO 1. Total de especies silvestres y series por países.

	Número sp. endémicas	Número sp. no endémicas	Número de series	Número total sp.
1. Grupo Sudamericano:				
Argentina	5	13	6	18
Bolivia	12	11	7	23
Brasil	1	2	1	3
Colombia	2	5	4	7
Chile	5	3	4	8
Ecuador	8	4	4	12
Panamá	0	2	1	2
Paraguay	0	2	1	2
Perú	55	6	9	61
Uruguay	0	2	1	2
Venezuela	2	2	2	4
2. Grupo Centro y Norte Americano:				
Costa Rica	0	1	1	1
Guatemala	0	5	4	5
México	17	10	8	27
U.S.A.	0	5	4	5

CUADRO 2. Grupos Taxonómicos de especies tuberíferas silvestres de Sudamérica y su distribución geográfica.

12 series con un total de 112 especies, 90 endémicas y 22 no endémicas

Series o Grupos Taxonómicos		Distribución
Serie ACAULIA	(ACA)	Argentina, Bolivia y Perú
Serie CIRCAEFOLIA	(CIR)	Bolivia
Serie CONICIBACCATA	(CON)	Bolivia, Colombia, Ecuador, Panamá, Perú y Venezuela (hasta México).
Serie COMMERSONIANA	(COM)	Argentina, Bolivia, Brasil, Paraguay y Uruguay.
Serie CUNEOLATA	(CUN)	Argentina, Bolivia, Chile y Perú
Serie ETUBEROSA	(ETU)	Argentina y Chile
Serie INGAEFOLIA	(ING)	Perú
Serie JUGLANDIFOLIA	(JUG)	Colombia, Ecuador y Perú
Serie MEGISTACROLOBA	(MEG)	Argentina, Bolivia y Perú
Serie OLMOSIANA	(OLM)	Perú
Serie PIURANA	(PIU)	Colombia, Ecuador y Perú
Serie TUBEROSA	(TUB)	Argentina, Bolivia, Colombia, Chile, Ecuadror, Perú y Venezuela

CUADRO 3. Especies tuberíferas silvestres endémicas.

País	Especie	Serie	2n	Total
Argentina	*S. sancta-rosae*	MEG	24	5
"	*S. kurtzianum*	TUB	24	
"	*S. spegazzinii*	"	24	
"	*S. venturii*	"	24	
"	*S. vernei*	"	24	
Bolivia	*S. capsicibaccatum*	CIR	24	12
"	*S. circaefolium*	"	24	
"	*S. violaceimarmoratum*	CON	24	
"	*S. yungasense*	COM	24	
"	*S. toralapanum*	MEG	24	
"	*S. ureyi*	"	?	
"	*S. brevicaule*	TUB	24	
"	*S. candolleanum*	"	24	
"	*S. doddsii*	"	?	
"	*S. gandarillasii*	"	24	
"	*S. torrecillasense*	"	?	
"	*S. virgultorum*	"	?	
Brasil	*S. calvescens*	COM	?	1
Colombia	*S. moscopanum*	CON	72	2
"	*S. lobbianum*	TUB	?	
Chile	*S. etuberosum*	ETU	24	5
"	*S. fernandezianum*	"	24	
"	*S. palustre*	"	?	
"	*S. subandinum*	"	?	
"	*S. rickii*	JUG	24	
Ecuador	*S. paucijugum*	CON	?	8
"	*S. tundalomense*	"	24	
"	*S. albornozii*	PIU	?	
"	*S. cyanophyllum*	"	?	
"	*S. solisii*	"	?	
"	*S. minutifoliolum*	TUB	?	
"	*S. regularifolium*	"	?	
"	*S. suffrutescens*	"	?	
Venezuela	*S. paramoense*	TUB	?	2
	S. filamentum	CON	?	
				35

CUADRO 4. Especies tuberíferas silvestres endémicas del Perú.

Especie	Serie	2n	Total
S. ayacuchense	CON	24	
S. buesii	CON	?	
S. contumazaense	CON	24	
S. chomatophilum	CON	24	
S. laxissimum	CON	24	
S. jaenense	CON	24	
S. neovargasii	CON	?	
S. urubambae	CON	?	
S. pillahuatense	CON	24	
S. villuspetalum	CON	?	
	CON		10
S. anamatophilum	CUN	24	
	CUN		1
S. ingaefolium	ING	24	
S. jalcae	ING	24	
S. rachialatum	ING	24	
	ING		3
S. lycopersicoides	JUG	24	
	JUG		1
S. dolichocremastrum	MEG	24	
S. hastiformum	MEG	24	
S. sogarandinum	MEG	24	
	MEG		3
S. olmosense	OLM	24	
	OLM		1
S. acroglossum	PIU	24	
S. cantense	PIU	24	
S. paucissectum	PIU	24	
S. piurae	PIU	24	
S. yamobambense	PIU	24	
	PIU		5
			24

CUADRO 5. Especies tuberíferas silvestres endémicas del Perú.

Especie	Serie	2n	Total
S. abbottianum	TUB	24	
S. acroscopicum	TUB	24	
S. amabile	TUB	24	
S. ambosinum	TUB	24	
S. bukasovii	TUB	24	
S. cajamarcense	TUB	24	
S. canasense	TUB	24	
S. coelestispetalum	TUB	24	
S. chancayense	TUB	24, 36	
S. chiquidenum	TUB	24	
S. gracilifrons	TUB	24	
S. huancabambense	TUB	24	
S. humectophilum	TUB	24	
S. hypacrarthrum	TUB	24	
S. immite	TUB	24, 36	
S. lignicaule	TUB	24	
S. marinasense	TUB	24	
S. medians	TUB	24, 36	
S. mochicense	TUB	24	
S. multiinterruptum	TUB	24	
S. nubicola	TUB	48	
S. orophilum	TUB	24	
S. pampasense	TUB	24	
S. pascoense	TUB	24	
S. rombilanceolatum	TUB	24	
S. soukupii	TUB	24	
S. tacnaense	TUB	24	
S. trinitense	TUB	?	
S. velardei	TUB	24	
S. weberbaueri	TUB	?	
S. wittmackii	TUB	24–48?	
	TUB		31

CUADRO 6. Especies tuberíferas silvestres no endémicas.

Países	Especies	Serie	2n
Argentina, Bolivia y Perú	S. acaule	ACA	48,60 y 72
Argentina, Brasil, Par. y Uruguay	S. commersoni	CON	24,36
Arg., Bolivia, Bras., Par. y Uruguay	S. chacoense	COM	24,36
Argentina y Bolivia	S. tarijense	COM	24
Argentina, Bolivia y Chile	S. infundibuliforme	CUN	24
Colombia, Ecuadro y Venezuela	S. colombianum	CON	48
Panamá, México	S. oxycarpum	CON	48
Panamá y Venezuela	S. woodsonii	CON	?
Argentina y Chile	S. brevidens	ETU	24
Colombia y Ecuador	S. juglandifolium	JUG	24
Colombia, Ecuador y Perú	S. ochranthum	JUG	24
Argentina y Bolivia	S. boliviense	MEG	24
Argentina, Bolivia y Perú	S. megistacrolobum	MEG	24
Colombia y Ecuador	S. tuquerrense	PIU	48
Colombia y Ecuador	S. andreanum	TUB	24
Argentina, Bolivia y Perú	S. leptophyes	TUB	24
Argentina y Bolivia	S. microdontum	TUB	24
Argentina y Chile	S. maglia	TUB	24,36
Argentina y Bolivia	S. oplocense	TUB	24,48
Bolivia y Perú	S. pumilum	TUB	24
Bolivia y Perú	S. sparsipilum	TUB	24,48
Argentina y Bolivia	S. vidaurrei	TUB	24

Finalmente, aunque no es del caso citar aquí la larga lista de especies silvestres sinónimas, completaremos la información consignando el Cuadro 7 donde se muestra las especies sudamericanas estimadas como hibridógenas incluyendo las del grupo cultivado.

Ahora, consideremos la existencia actual de especies acumuladas en los Bancos de Germoplasma. Tomando solo como ejemplo el de Sturgeon Bay en Estados Unidos de Norte América, la última lista circulada en Marzo del presente año, contiene 61 especies para el grupo cultivado y silvestre, de las cuales 31 son oriundas de Sud América. Esto significa que aproximadamente solo un 35% del reservorio sudamericano se encuentra en colecciones vivas en el Banco Germoplásmico que al momento seguramente constituye el más grande del mundo.

En cuanto a los Bancos de Germoplasma existentes en Sud América podemos decir que los países que más se han preocupado del problema en las dos últimas décadas son Argentina que a través del Programa de Papa del INTA y un Convenio con la República Federal Alemana, según amable información personal del Dr. K.A. Okada, tienen en Balcarce y la región Noroeste colecciones vivas donde existen casi la totalidad de especies silvestres argentinas y cultivares nativos del país. El Gobierno de Chile ha estado tratando de mantener y salvaguardar los cultivares chilotas que ya se encuentran en vías de extinción acumulando colecciones vivas en Carillanga cerca de Temunco donde hemos aportado con un duplicado de las colecciones que hicimos en nuestra Expedición a Chiloé y los Chonos en 1969. El INIAP del Ecuador, mantiene un Banco en su Estación Experimental de Santa Catalina, cerca de Quito, donde han reunido principalmente sus cultivares nativos. Igualmente Colombia, en su Programa de Papa del ICA ha logrado reunir una gran cantidad de papas nativas de la región andina.

En cuanto al Perú, podemos decir con seguridad que es el país donde se cuenta con las colecciones vivas más completas de los cultivares indígenas de Perú, Bolivia y Chile. En esta oportunidad, informaremos que el Banco de Germoplasma de Papa que mantenemos en la Universidad Agraria en colaboración con el Ing° Oscar Blanco Galdos de la Universidad del Cuzco, cuenta con más de 2600 introducciones. Por otra parte estamos informados que el Banco de Germoplasma del Programa Nacional de Papa del Ministerio de Agricultura (ahora del CIP) tiene a la fecha más de 3000 entradas. En otras regiones del país existen también colecciones vivas locales tales como las propiciadas por la Universidad de Huamanga en Ayacucho, la Universidad Comunal del Centro en Huancayo y la Universidad del Altiplano en Puno.

CUADRO 7. Híbridos naturales o especies hibridógenas.

1. Grupo Silvestre:

Distribución	Híbrido	Posibles Progenitores	2n
Argentina	S. x bruecheri	S. acaule x S. megistacrolobum	36
Argentina	S. x rechei	S. microdontum x S. kurtzianum	24
Argentina	S. x ruiz-leali	S. chacoense x S. kurtzianum	24
Argentina	S. x setulosistylum	S. chacoense x S. spegazzinii	24
Bolivia	S. x berthaultii	S. tarijense x S. sparsipilum	24
Perú	S. x arac-papa	S. x raphanifolium x canasense	24
Perú	S. x raphanifolium	S. megistacrolobum x S. canasense	24

2. Grupo Cultivado:

Distribución			
Perú y Bolivia	S. x chaucha	ssp. andígena x S. stenotomum	36
Argentina, Perú y Boliv.	S. x curtilobum	S. juzepczukii x ssp. andígena	36
Argentina, Perú y Boliv.	S. x juzepczukii	S. acaule x S. stenotomum	36

Con todo, diremos que contrariamente a lo ocurrido en los Bancos de Germoplasma de Estados Unidos de Norte América y Europa (con excepción de Rusia y Alemania Oriental) donde el interés principal ha sido y es en el grupo de especies silvestres, en los Bancos Sudamericanos se ha dado primordial interés a los cultivares primitivos. Podemos asegurar sin temor a equivocarnos que si se suma la totalidad de especies silvestres mantenidas en los Bancos Sudamericanos, no deben llegar ni siquiera a la total cantidad de especies mantenidas en Sturgeon Bay, Wisconsin.

Para terminar, nos referiremos muy brevemente al germoplasma del grupo cultivado. La clasificación de las papas primitivas cultivadas en Sudamérica se amplió notablemente a partir de la tercera década de nuestro siglo en que los investigadores rusos (Juzepczuk, 41,42; Bukasov, 12,18) proponen nuevas concepciones como resultado de sus expediciones colectoras a América. De este modo, a la fecha, según la última publicación monográfica editada en Leningrado (Bukasov et al. 19) los científicos soviéticos proponen un total de 18 especies cultivadas distribuídas en 4 niveles de ploidía. Sin embargo, una tendencia extremadamente opuesta a la de los rusos ha sido planteada por Dodds (27) quien considera un total de solo tres especies. Por último, el profesor Hawkes (38) propone un sistema de clasificación más moderado y considera un total de 7 especies. En las clasificaciones que estamos haciendo en nuestro Banco de Germoplasma coincidimos en gran parte con el sistema del Dr. Hawkes.

A la fecha tenemos estudiadas cerca de 1500 introducciones, de las cuales más de 900 son tetraploides representadas por S. tuberosum ssp. tuberosum de Chile S. tuberosum ssp. andígena (Argentina, Bolivia, Perú, Ecuador, Colombia y Venezuela); 350 diploides representadas por S. ajanhuiri (Bolivia y Perú) y S. goniocalyx (Perú), S. phureja (Bolivia, Perú, Ecuador y Colombia), S. stenotomum (Bolivia, Perú y Ecuador), 180 triploides representadas por S. x chaucha (Perú y Bolivia) y S. x Juzepczukii (Argentina, Bolivia y Perú) y 35 pentaploides representadas por S. x curtilobum (Argentina, Perú y Bolivia).

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THE INTERNATIONAL POTATO CENTER'S GERMPLASM BANK

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Although CIP did not become a legal entity until January 20, 1971, planning money became available in 1970. Using this source of funds, CIP accepted financial responsibility for the Potato Germplasm Collection of the National Potato Program. A newly graduated Peruvian agronomist was hired to work with the collection located in the Central Sierra at Huancayo, with North Carolina State University funds in 1969. CIP assumed responsibility for the position in 1970.

I was responsible for the development of a National Seed Production Program also located in the Huancayo area and became involved with the collection since the problems of disease elimination are similar. My initial work with the collection was mainly the establishment of a rough ro - guing program.

The Peruvian working with the collection, Ing. Zósimo Huamán left in August 1971 to study for an advanced degree in genetic maintenance and conservation with Professor J. G. Hawkes at the University of Birmingham in England. He will return in 1973 to work for the Center with his Ph.D. residence requirements completed. At the time of his return, a British scien - tist presently working at the University of Birmingham will also come to the Center to work on germplasm and Professor Hawkes will be provided as a short term consultant through the British Overseas Development Program.

With the departure of Ing. Huamán, CIP hired Ing. Juan Aguilar to work with the collection. I have been and will continue to supervise his work until those being trained return.

In 1970, when CIP accepted the responsibility for the collection,

it consisted of approximately 1564 clones of cultivated potatoes. 407 clones were immediately added from a collecting trip of Ing. Huamán and Ing. Luis López of Colombia. 229 clones came from the Ministry of Agriculture collection in Cuzco and 75 others from a private collection in Ayacucho. Miscellaneous clones were continuously collected by various people.

In 1971, 209 clones were added, principally from two trips by Ing. Huamán. The first, from a collecting trip headed by Dr. J.G. Hawkes of the University of Birmingham, England and by Mr. J.P. Hjerting of the University Botanic Gardens, Copenhagen, Denmark. This group collected in Southern Peru and Bolivia. The second collecting trip was with Ing. Luis Burga in the Cuzco area.

In 1972, up to this date, only 32 clones have been added, 19 of these from the Cuzco collection. A total of 2505 clones are presently registered in the collection.

Of the original 1564 clones of 1970, 847 are without any type of data -- that is, no local names, no location collected, etc. Another 194 clones are listed only by local names, with no other data. These last are thought to have originated in southern Peru. No collections have been made from northern Peru since 1969 because of the bacterial disease Pseudomonas solanacearum. With the addition of new facilities being constructed this year, a quarantine program can be initiated in La Molina and collections can again be made in northern Peru.

Since Ing. Huamán left for advance study, I have de-emphasized collecting and placed a major effort on trying to clean up the collection. This has consisted of planting 15 tubers of each clone and initiating a vigorous roguing program. Where possible, the plants most severely infected with virus have been removed and many mixtures eliminated. The large number of mixtures found has necessitated some basic data collecting for identification, such as tuber color and shape, flesh color and various vine characteristics as well as flower and another color. This past growing season 12 entries of a commercial hybrid were eliminated and we are down to about 85 mixed clones, now labeled A & B.

In addition to the 2505 clones in this collection, we are presently maintaining 3 other small collections. The first consists of 144 clones collected on a second trip by Ing. Luis López of Colombia in southern Peru. The second, consisting of 320 clones, was donated by the Universidad del Centro,

Huancayo. The third, of 61 clones, represents a group of Chilean tetraploids sent here in 1971 by the Scottish Plant Breeding Station to see if we could get them to flower. (our efforts to date have been unsuccessful). The first two groups will be integrated into the collection when more data has been accumulated. We hope to avoid unnecessary duplications.

Open pollinated botanical seed is being collected as fast as possible from all these clones as a method of preservation. Each year, 40-50 clones have been lost. This loss can be attributed to several factors. The highest mortality rate occurs the first planting after introduction caused by clones sprouting when it is impossible to plant or by clones that have to be induced to sprout to conform to planting dates. Viruses and other diseases are the second most important contributing factor. Careless tractor drivers are also a factor.

In addition to the cultivated germplasm, the National Program had in 1970, 216 clones of wild species. Of these 177 originated from the United States IR-1 collection in Sturgeon Bay, Wisconsin. In 1971, 168 entries were added from the afore mentioned J.G. Hawkes collection trip in Bolivia and southern Peru. From late 1970 to date, 47 Peruvian entries have been added by various persons. In 1972, 120 entries were added by the National Potato Program, all from the IR-1 collection. At this moment there are 551 entries of wild species. There are also 39 hybrids and 11 entries of other solanaceous genera, not potatoes.

Most of the wild species that have not been previously converted to or collected as botanical seed are being propagated and maintained in tuber form in La Molina until facilities and qualified personnel are available to properly handle them. No true seed, is being converted to tubers for further increase of botanical seed at this time. This program must be initiated soon.

There are several private collections in Peru that can be added to this collection when time and facilities permit. Only half of the Ministry's Cuzco collection has been integrated. Many areas of the country are yet to be explored for both cultivated and wild species.

In summary, there are about 3030 cultivated clones, 551 wild clones, 39 hybrids and 11 non-potatoes in the CIP collection for a grand total of 3731 clones. Some of these are duplicates, which through time will be eliminated with proper data. The cultivated clones represent 9 species or sub-species. The wild clones represent over 60 species from practically every country having wild potatoes.

THIRD SESSION

UTILIZATION OF GERM PLASM IN BREEDING PROGRAMS

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UTILIZATION OF GERM PLASM IN BREEDING PROGRAMS - USE OF CULTIVATED TETRAPLOIDS

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To be successful, a breeding program must successfully incorporate the following components:

1. A clearly defined set of realistic objectives of what will be required for a new variety to be accepted.
2. A rich reservoir of useful genetic variability.
3. An efficient system for discarding clones which do not meet the criteria of the objectives.
4. A program of seed multiplication and distribution.

To these, the breeder of potatoes must add one other factor and that is a seed maintenance program that will keep his breeder seed free of virus contamination.

The bulk of the effort that has been invested in potato breeding has been with tetraploids in the temperate regions of the world. Of the four factors listed, the one which has fallen the shortest of its potential is the use of available genetic variability. For the most part, temperate zone potato breeders have tried to achieve their objectives through the reassortment of the gene pool that is residual from the initial introductions of andigena germ plasm started 400 years ago. Even if the recorded introductions are taken as but a token of the actual number, it seems reasonable to assume that the germ plasm they contained was only a small portion of what existed in the Andean center of origin at that time (Cardenas 1966). Certainly the gene pool was further reduced by losses due to unadaptability and diseases, particularly the late blight epidemics of the 1840's (Simmonds 1964). The fact that this limited gene pool has been as rewarding as it has been, must be due in large part to

the variability that can be carried in heterozygous tetraploids.

Potato breeders have not been oblivous of the variability that exists in the Andean cultivars. On a few occasions, such as the importations the Rev. Chauncey Goodrich (1863) made into N.Y. State between 1848 and 1852, a limited amount of new andigena germ plasm has been added to the breeder's pool. In the 1940's an andigena clone was used in crosses to provide resistance to race A of the golden nematode. Extensive collections of andigena cultivars have been available for several years outside South America in collections such as the Commonwealth Potato Collection in England, the Erwin Bauer Sortiment in Germany, and the IR-1 Collection in the U.S. Until the last decade breeders have tended to neglect these collections except when they were seeking single genes for specific purposes, generally disease resistance. This attitude cannot be condemned when one considers that the number of years a breeder can work and the number of clones he can observe, raise the odds of producing a truly successful variety to about one in a lifetime. To try to use andigena as it exists in germ plasm collections would appear to reduce the chances of success. Even though one of Goodrich's clones Garnet Chile, eventually figured very extensively in N. American potato pedigrees, he was quite discouraged about his effort. I quote from his 1863 publication:

> " In 1848, I received a variety from Bogotá, South America,--. This variety was so entirely too late in its maturity as speedily to decline---. In 1850, I received another variety from the same place, of a little earlier maturity, but it could never be adapted to our climate, and after a few years of trial was rejected. In 1851, I received 8 varieties from Panama, supposed to have been brought from the coast of Chile---. One of these was exactly like the last sort above noticed. One other was afterwards extensively cultivated by me under the name of Rough Purple Chili. It was the parent of my seedling, the Carnet Chili. The 6 remaining varieties were all too late for this climate, one of them by only a month, but the others probably by 2 or 3 months.
>
> In December 1852, a neighbor returning from the west coast of S. America brought me varieties supposed to have been grown in the mountains---. They were both entirely too late in maturity. In 1852 I originated 4210 sorts which is considerably more than one fourth of all I have originated. They were of 11 different families, about 1/2 of which were from the balls of S. American varieties---. Nearly all these families of S. American origin were ruinously late, as their parents before them had been, though often the seedlings were an improve-

ment on the parent in time of maturity. Theoretically, I doubt the propriety of importing sorts from climates very different from our own."

Anyone else in the temperate zones attempting to incorporate andigena into his breeding program has shared these experiences of late maturity, poor tuber shape and deep eyes, and foliage not in conformity with seed certifier's concept. Another major deterrent to the use of andigena has been its reputation for susceptibility to late blight. (Simmonds and Malcomson 1967). This was particularly effective in the decades that breeding for blight resistance was the core of most breeding programs.

The interest in andigena at Cornell stemmed from the golden nematode resistance program. As early as the first backcross it became evident that the progrenies with andigena heritage were outyielding the progenies with only tuberosum background. Breeders in the USDA and from Europe shared the same impression. The fact that this coincided with the beginning of this era of awareness of the value of the world germ plasm of other major food crops certainly had its impact. The major reinforcement for my own conviction came in 1964 with the opportunity given me by the Rockefeller Foundation to observe the heterosis manifested in the andigena-tuberosum hybrids being produced in the breeding programs in Peru, Ecuador, and Colombia. Carlos Ochoa and Nelson Estrada gave me true seeds of andigena crosses which gave me a start on a selection program. The same winter, I learned of the start N.W. Simmonds had made in 1960 at the John Innes Institute with the Commonwealth Potato Collection (CPC) of andigena, to recreate the adapted tuberosum like characteristics expected in European varieties (Simmonds 1966). When late blight susceptibility appeared to be a major deterrent to the use of this material, he combined a selection for adaptability with selection for blight resistance. He sent me seed of this material and I planted 284 hills of it and 347 hills of the S. American material as spaced plants in the field in 1965. About 40 clones were saved from each of the two populations on the basis of yield of tubers. In general, the material from Simmonds which had had 1 or 2 cycles of selection was higher yielding than the population which came directly from S. America. The selected clones were put in the greenhouse during the winter and invididual crosses were attempted among them. The fertility was very poor and only 14 of the S. American clones and 9 of the CPC clones contributed to the next generation. In 1967 approximately 2000 seedlings from these crosses were transplanted directly to the field. An additional 2000 seedlings from seed from the 1966 cycle of Simmond's selection program were also included. At harvest time, fruits were saved from plants with the best tubers. From the more advanced cycle from Simmonds, 139 clones were saved. From the earlier cycle from Simmonds, 83 were saved. From the clones with one prior selection only 33 were saved.

Most of the selected clones were tested for their reaction to verticillium wilt and scab and promising levels of resistance were found in several of the clones. That year Dr. Thurston joined the project and he tested the clones for blight resistance in the greenhouse and in Mexico. In 1968, 4000 plants from the seeds saved the previous year were transplanted. At harvest-time, 197 selections were made of which only 22 were related to the direct S. American introductions. The seeds from these selections were sown and the seedlings transplanted into trays of peat pots and those segregating for blight resistance were tested for late blight. 4000 clones were planted in the field in the spring of 1969. 428 selections were made, 11 of which were from the direct introductions. An unusual and severe infection of PVY occurred which further reduced the size of the population to about 70 clones. The healthy clones were placed in the greenhouse for crossing during the winter to guarantee maximum panmixis. The present population derived from these crosses consists of 6225 spaced plants.

This program of selection has been very rewarding. The initial population was very late in maturity, with many clones setting no tubers and the rest being very small and poorly shaped. Four cycles of selection have produced clones with tuber yields in spaced plants equal to or better than similarly unselected tuberosum progenies. Tuber shape has improved considerably, but deep eyes are still common in many clones. Many interesting patterns of pigment distribution have been maintained as well as both yellow and white flesh color. In general, the clones exhibit a greater dormancy than in experienced with tuberosum. Foliage type has not changed much except to reduce the volume of tops. This is not unexpected as there has not been much selection pressure applied for foliage type. Some clones have the broad leaves and wide leaf angle associated with tuberosum so selection for this character should not be difficult.

Our experience parallels that reported by Simmonds in 1966. Their population responded strongly to blight resistance, earliness and size of crop at harvest, and changed slightly in appearance and pigmentation of tubers, size of leaves, and amount of flowering. In 1969, Glendinning grew seedlings of CPC andigena clones, neo-tuberosum clones from their selection program, and tuberosum clones from the regular breeding program. The plot was planted June 25. At the end of August the percentage of plants tubered was 7% for unselected andigena, 63% for neo-tuberosum, and 100% for tuberosum; thus revealing the selection gain for earliness. At the end of October, the yield per plant of andigena clones was 170 grams, of neo-tuberosum was 810 grams, and of tuberosum was 630 grams. The clones that tubered were replanted on May 5, 1970. In early September the yield per plant of the neo-tuber-

osum and tuberosum were essentially the same and both considerably greater than andigena. In mid October, the neo-tuberosum clones outyielded the tuberosum clones by 345 grams per plant. Glendinning reported on a trial in 1971 in which Pentland Crown was planted as a control among the neo-tuberosum clones. On the 4th of October, most neo-tuberosum clones equalled Crown in yield.

This limited population of ours has been surprisingly potent in what it has contributed to all the tests for resistance we have given it. Primary pressure has been placed upon late blight in order to capitalize on the preliminary gains made by the British workers. Evaluation of the current population in a growth chamber has shown 40% of the clones to be resistant with some progenies being as high as 79%. A sample from the 1969 British cycle produced 63% resistant. The clones resistant in the growth chamber tests are being field tested in the Toluca Valley of Mexico. Previous tests indicate we can expect a much smaller percentage to survive that test, but that the ones which do will be the best parents for the next cycle of selection. The best test of any breeding program is the ability to successfully incorporate a characteristic in an acceptable variety. Estrada and Guzman (1969) have produced varieties for Colombia with blight resistance they have developed in Andigena. Limited tests for scab resistance have produced clones with levels of resistance comparable to traditional sources of resistance used in breeding programs. We have identified clones with resistance to verticillium wilt, but due to the complication with maturity, these need to be tested further. Even the epidemic of PVY had a productive facet. The high rate of infection made the few families which almost completely escaped infection quite obvious. These have been subsequently tested in two additional years of field exposure and have resisted infection. Now we are looking at the same population for resistance to aphids and the rootknot nematode.

In addition to resistance to late blight, verticillium wilt, scab and virus Y, others (Ross and Rowe 1969) have reported Group Andigena to be a source of resistance for viruses A, X, Leaf Roll, S, and M; fusarium dry rot, fusarium wilt, ring rot, and bacterial wilt. In addition to the well known gene for resistance to Race A of the golden nematode, resistance has been reported for the rootknot nematode. There has been less evaluation made for insect resistance, but resistances to leaf hoppers, flea beetles, potato aphids, and green peach aphids have been identified (Radcliffe and Lauer 1966, 1968). Richardson and Estrada (1971) and others have reported on frost resistance in andigena.

The program of selection at Pentlandfield has relied heavily on natural selection, particularly for disease resistance. Glendinning estimates half their clones to be resistant to virus X, one third to be resistant to virus Y, three fourths to be immune to wart, and almost all plants survive to harvest at Cornwall where blight is epidemic, but less severe than in Toluca, Mexico. One lesson I take from these experiences is that Group Andigena is an extremely variable population that responds well to organized programs of selection. Another lesson is that large populations are required and a conscious effort needs to be made to prevent too great a loss of germ plasm.

The stimulus of the success of this program and the experiences earned through working with it, have induced us to start a new series of selection cycles with a broader genetic base. In this population we hope to preserve more of the initial variability. In 1970 about 40,000 plants were grown in the greenhouse and from those that tubered, 17,000 plants of 910 accessions were grown in 1971. These accessions were obtained from Peru, Ecuador, and Colombia as well as the IR-1 and CPC collections. At harvest time fruit was saved from any clones producing tubers. This resulted in 1861 hills being saved from 587 families. Some of the accessions which did not tuber well in the greenhouse were replanted in the spring of 1971 and transplanted directly to the field. It was our observation that even though the transplants got off to a faster start and grew better all summer long, they tubered more poorly than their tuber planted full sibs. I presume this is due to the screening out of short day types in the greenhouse tuber production. Subsequent additions of seed will increase the number of families to about 625. Future selection will be practiced within families in an effort to preserve the variation between families. It is our anticipation that we have already experienced the greatest loss of families and that an overall population size of 35,000 will give ample opportunity to select within progenies. To the extent we can identify the country of origin, our new population has as its distribution of origin the following: 41% from Peru, 17% from Argentina, 16% from Bolivia, 13% from Colombia, 5% from Mexico, 5% from Ecuador, and 2% from Chile. The Glendinning population was probably about 45% Bolivian, 45% Peruvian, and 10% Colombian.

Glendinning estimates that the first cycles of selection in that population reduced the number of clones from 273 to between 70 and 100. Our own most advanced andigena population can be traced back to 19 females, only 3 of which were selected in 1965.

Maris, at Wageningen, Netherlands, began a selection program with 59 IR-1 andigena introductions in 1967. His original population was 34%

Colombian, 22% Peruvian, 17% Bolivian, and 10% Argentinian and Mexican. In the greenhouse under short days, 94% tubered. These tubers were planted in the field the following summer, and only 55% tubered under long days. He estimates that the present population represents approximately half the original number of accessions. In addition to selection for yield and tuber characteristics, the Dutch andigena population has been selected for field resistance to late blight and scab.

For those areas of present and potential potato production which are not at high elevations in the lower latitudes, it seems as if the greatest value that can come from andigena is in hybrid combination with tuberosum varieties. Experience with other crops and theory of gene action indicates that heterosis for yield is greatest when hybrids are produced between unrelated parents. Where one or both the parents are unadapted, it may be necessary to do preliminary selection on the parents to make them more adapted so that the variation in the hybrids overlaps with the conditions of culture. Experience at Cornell has been that hybrids with unselected andigena are generally too late to reach their yield potential. In spite of this a few of the hybrids have yielded as much as the highest yielding tuberosum clones. Using andigenas partially adapted to long days in hybrid combination with tuberosum varieties, D.R. Glendinning (1969) found these hybrids outyielded tuberosum x tuberosum hybrids by 13%. It was his conclusion that pre selection among the andigenas for desirable characters would produce acceptable high yielding hybrids when used in combination with tuberosum clones. We have initiated an experiment to measure heterosis in andigena-tuberosum hybrids using our advanced andigena selections. Andigena x andigeno hybrids, tuberosum x andigena hybrids, and tuberosum x tuberosum hybrids have been planted at two elevations in Mexico and Colombia, one in the U.S., and will be planted at two in Peru. One of the objectives is to determine whether selection of andigena at an unadapted location produces a population with insensitivity to factors by which the present and prior locations differ.

Another series of reciprocal crosses between andigena and tuberosum clones is being evaluated to determine whether the source of cytoplasm will have any effect on heterosis. Two years of tests with two different sets of andigena and tuberosum clones have produced significant but contradictory results. In 1970 a progeny test of tuber planted plots at close spacing produced 5 out of 6 comparisons in which the hybrids with tuberosum cytoplasm outyielded these with andigena cytoplasm. In 1971, paired comparisons of reciprocals planted with transplants at wide spacing produced 12 out of 13 comparisons in which the hybrids with andigena cytoplasm outyielded these with tuberosum cytoplasm. The trials are being repeated this summer using

tubers as seed pieces and transplants at both wide and narrow spacing.

During the early cycles of selection we have used seeds from open pollinated fruits produced in the field. Unfortunately and surprisingly there is no precise information about what proportion of this seed is produced by cross pollination. Dodds (in Correll 1962), Glendinning (private correspondence) and Free (1970) credit solitary wasps and bumble bees as the agents of pollination. This has been my own experience in N.Y. One year I placed screen cages over plants which had already set fruit and none of the protected flowers set fruit as long as the cages were in place. From this I anticipated considerable cross fertilization. However, the progenies did not bear this out. Open pollinated fruits from blight resistant clones segregated about 2/3 resistant offspring whereas susceptible clones produced almost no resistant offspring. In 1969 Glendinning made observations on bee activity that would indicate they are more apt to be agents of self pollination than cross pollination and the offspring he observed bore this out. Further studies of this in 1971 gave further evidence of more inbreeding than cross fertilization. Bas Maris reported to me that male sterile andigena clones have never produced fruits in the field at Wageningen, Netherlands. This means that special efforts must be made to maximize cross fertilization in a mass selection program. A system we have used that has been reasonably simple and successful is to collect pollen in bulk and use it in manually pollinating other flowers. Maris follows a heirarchal system of combining parents through successive specific crosses.

Up to now the major effort to adapt andigena to a climate different from its own habitat has been in the north temperate regions identified with tuberosum cultivation. The same procedure should be equally effective and relatively more productive for those regions of the world where the potato is developing a new place in its agriculture (Simmonds 1971). Rather than attempt to mold highly selected tuberosum into a new niche, it is much more likely that useful genetic variability can be found in andigena. If the new regions are marginally suited for tuberosum then the use of tuberosum and selected andigena hybrids may provide the greatest opportunity for success.

Wherever andigena germ plasm is subjected to selection there is going to be a reduction in potential variability. Even if selection is not consciously applied, the natural selection against those which do not tuberize, are susceptible to insects or diseases, or sprout prematurely or too late will remove clones from the gene pool. There is of necessity the same type of natural selection occuring in the native habitat of the group Andigena, however, any attempts to maintain this collection in an alternate environment is but an

additional screen that reduces variability further. For this reason the International Potato Center can do a great service to potato improvement throughout the world by serving as the primary center for the preservation of andigena germ plasm. Other collections, such as the IR-1 and CPC collections are extremely useful to the breeders working in those regions. The two kinds of collections, one in the Andes and the others in specialized regions, are complementary to each other. The one serves as a bank for maximum germ plasm preservation and the others bring the collection closer to the breeders to evaluate and to facilitate its utilization.

The potatoes of the Andes are a priceless food resource for the entire world. It is only proper that an international agency such as the International Potato Center assume the responsibility and cost of collection, maintenance, and distribution of this resource. It is to the credit of the nation of Peru that they are willing to be the host for this Center and share this genetic resource.

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THE USE OF CULTIVATED DIPLOID SOLANUM SPECIES IN POTATO BREEDING

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In recent years an increasing interest has developed in the possibilities of breeding potatoes at the diploid level. The work of Hougas and Peloquin (7, 8, 9, 10, 11, 14) and their co-workers (5, 12, 13, 16, 17, 18, 19, 20, 21) has given impetus to this approach to potato improvement. In their paper on "the potential of potato haploids in breeding and genetic research", Hougas and Peloquin (8) have presented most of the arguments favoring genetic studies and breeding at the diploid level as contrasted to the tetraploid. Chase, in 1963 (1) proposed an elaborate ten-step scheme for the exploitation of Hougas and Peloquin's diploid parthenotes of S. tuberosum along with other diploid stocks.

Chase, like most others, has considered that it would be desirable, perhaps necessary, to return plant materials to the tetraploid level for commercial potato production. Whether this step is necessary is yet to be determined. Evidence to date on this point is conflicting.

In one study, Rowe (17) compared the performance of 15 diploid clones with their vegetatively doubled counterparts. The clones were selected from families of S. tuberosum Group Phureja x haploids of Group Tuberosum. The diploid clones produced more stems and were taller 4 weeks after planting. The diploids also flowered earlier and produced more total tuber yield. In another study, Rowe (18) compared the performance of 11 diploid and 11 tetraploid hybrid families. The hybrid families were again from crosses of Group Phureja x derived diploids (haploids) of Tuberosum. The tetraploid families were significantly higher in yield than the diploids when grown from botanical seed, but the differences in yield disappeared when the families were vegetatively propagated. Rowe's data also indicated that the diploid families had more within-population variability, providing evidence that diploid potatoes will respond to selection faster than tetraploids.

The work of Mendiburu and Peloquin (13) produced heterotic tetraploids outyielding their heterotic diploid "full sibs" by 50 per cent. These workers produced tetraploids by making 4x-2x and 2x-2x crosses in which unreduced gametes functioned. This sexual polyploidization did not involve inbreeding, whereas vegetative doubling does theoretically involve some inbreeding.

Perhaps inbreeding plays a greater role in the expression of yield than does plidy level per se. In Table 1, a comparison of coefficients of inbreeding is presented for certain combinations. As indicated, if one vegetatively doubles the chromosome number of a heterozygous diploid, the coefficient of inbreeding, F, is immediately 0.333, the approximate equivalent of the S_2 in a tetraploid, and greater than F_5 in half-sib mating diploids.

From this it can be concluded that hybridization will likely be the final step in any program of utilization of tetraploids, whether derived from diploids or whether naturally occurring.

As indicated earlier, one of the probable major advantages of diploids is their more rapid response to selection. This could be a very great advantage in attempting to introduce potatoes into new environmental situations or for isolating more productive genotypes for specific environments.

TABLE 1.- Certain coefficients of inbreeding in potatoes. After Wright (29).

Half-sib mating diploids	Selfing tetraploids	Doubling heterozygous diploids (X_1X_2)
$F_0 = 0$	$F_0 = 0$	$F_0 = 0$
$F_1 = 0$	$F_1 = .166$	($X_1X_1X_2X_2$)
$F_2 = .125$	$F_2 = .305$	$F = .333$
$F_3 = .188$	$F_3 = .421$	
$F_4 = .250$		
$F_5 = .304$		

The theory of this more rapid response has been illustrated graphically by Stebbins (28) (Figure 1). He shows the distribution of variants for a hypothetical quantitative character at the two levels of ploidy for comparison. The diploid offers the greater opportunity for selecting for genetic advance.

To date, consideration of breeding at the diploid level has always involved the derived diploids from Group Tuberosum. Other diploids have entered the picture primarily as sources of disease and insect resistance to be transferred largely through back cross programs. No systematic effort has been made to improve the diploid cultivars themselves through breeding. Diploid clones being grown commercially in South America today are largely unimproved native cultivars. Certainly there is a much greater potential for production than has been heretofore exploited. New clones selected for adaptation to specific environments and for greater yield incorporated with other valuable traits found in these diploids would be a major contribution to potato production for both the highland and lowland tropical regions. In addition, to provide a broader genetic base for breeding at the tuberosum haploid (derived diploid) level, new germ plasm from the cultivated diploids should be made available. This germ plasm would be more directly usable outside the tropics if it were adapted to the temperate zone.

Two diploids (2n = 24) S. phureja and S. stenotomum, cultivated in the Andes of South America, are short-day types. It is agreed that these two groups are very closely related to the cultivated tetraploids, and there is evidence (2, 3, 4) that one or both are progenitors of subsp. andigenum. Both diploids contain valuable genetic characters (15). Another diploid species, S. ajanhuiri, is grown at high altitudes in Southern Peru and Northern Bolivia. This species is valuable for its frost resistance. It is thought to be derived from S. stenotomum by a complex series of natural crosses (6).

Simmonds (27) has described six years of progress in a long-term experiment to re-create the tetraploid Tuberosum Group of potatoes from South American tetraploid stocks (the Andigenum Group). The purpose of the experiments is to determine causal factors in the evolution of the Tuberosum Group and to provide a broad base of genetic adaptation for use in potato breeding (22, 23, 24, 25, 26). Simmonds has obtained favorable responses to selection for adaptation in a wide range of characters. He has carried two selection programs in parallel: mass selection and pedigree selection. The populations have shown strong responses to mass, semi-natural selection for day-length reaction, and for resistance to late blight, but progress in improving "commercial" tuber characters was greatest under pedigree selection.

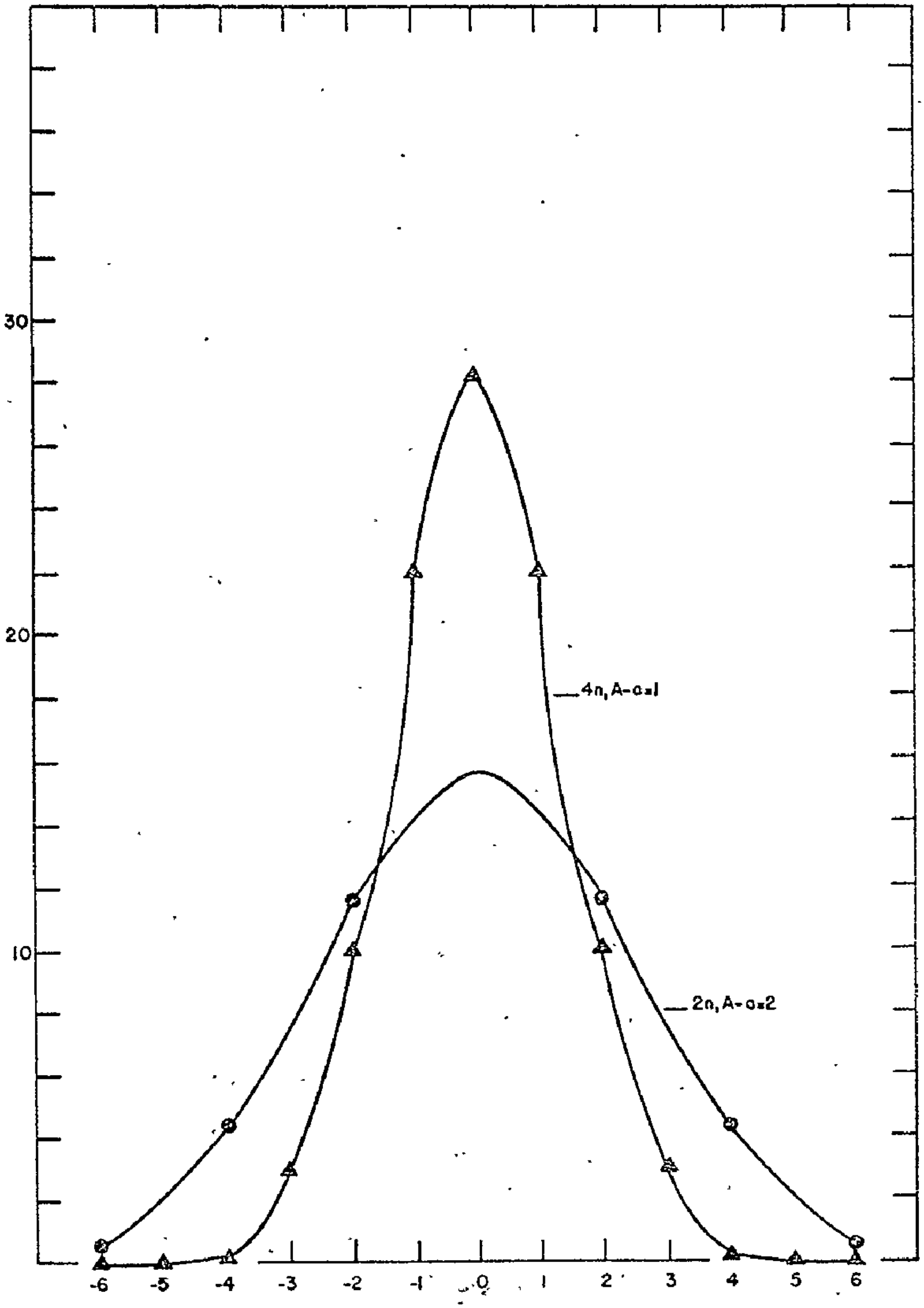


FIGURE 1. From Stebbins (28)

With this background information, we have conducted preliminary trials in selection within S. phureja and S. stenotomum at the Mountain Horticultural Crops Research Station, Fletcher, North Carolina, using plant materials obtained from the IR-1 project at Sturgeon Bay, Wisconsin. Populations of segregates from these cultivated diploids can be successfully grown in North Carolina. The climate at Fletcher features moderate temperatures during the long summer days and has an average frost-free period following the autumnal equinox sufficient to permit tuberization of short-day species. (Fig. 2). This affords us a unique opportunity to carry a dual selection program. One can select for changes in response to length of day during the summer and can then select for improved horticultural characters in the autumn. Possibility for success in one of the two selection objectives is independent of the other.

Objectives

With the initial successes of isolating clones which tuberize under the long-day photoperiod, we have begun a more comprehensive program with the following primary objectives:

1. To isolate and identify superior diploid clones for direct use in both the highland and lowland tropics.

2. To study the adaptation to the temperate zone of diploid Andean Solanum species as potential sources of new germ plasm for commercial exploitation.

Procedure

The following procedures have been or are being implemented to achieve the above objectives.

a) Clones of the cultivated diploids S. ajanhuiri, S. phureja, and S. stenotomum were obtained from the International Center and from Inter-Regional Potato Introduction Station, Sturgeon Bay, Wisconsin. The program was begun with 25 families of S. phureja and 11 families of S. stenotomum. New families are being added annually.

b) Clonally propagated materials are planted in the field at Fletcher and seed-propagated segregates are started in the University greenhouses at Raleigh and transplanted to the field at Fletcher.

c) Two basic types of selection are being practiced and compared for progress.

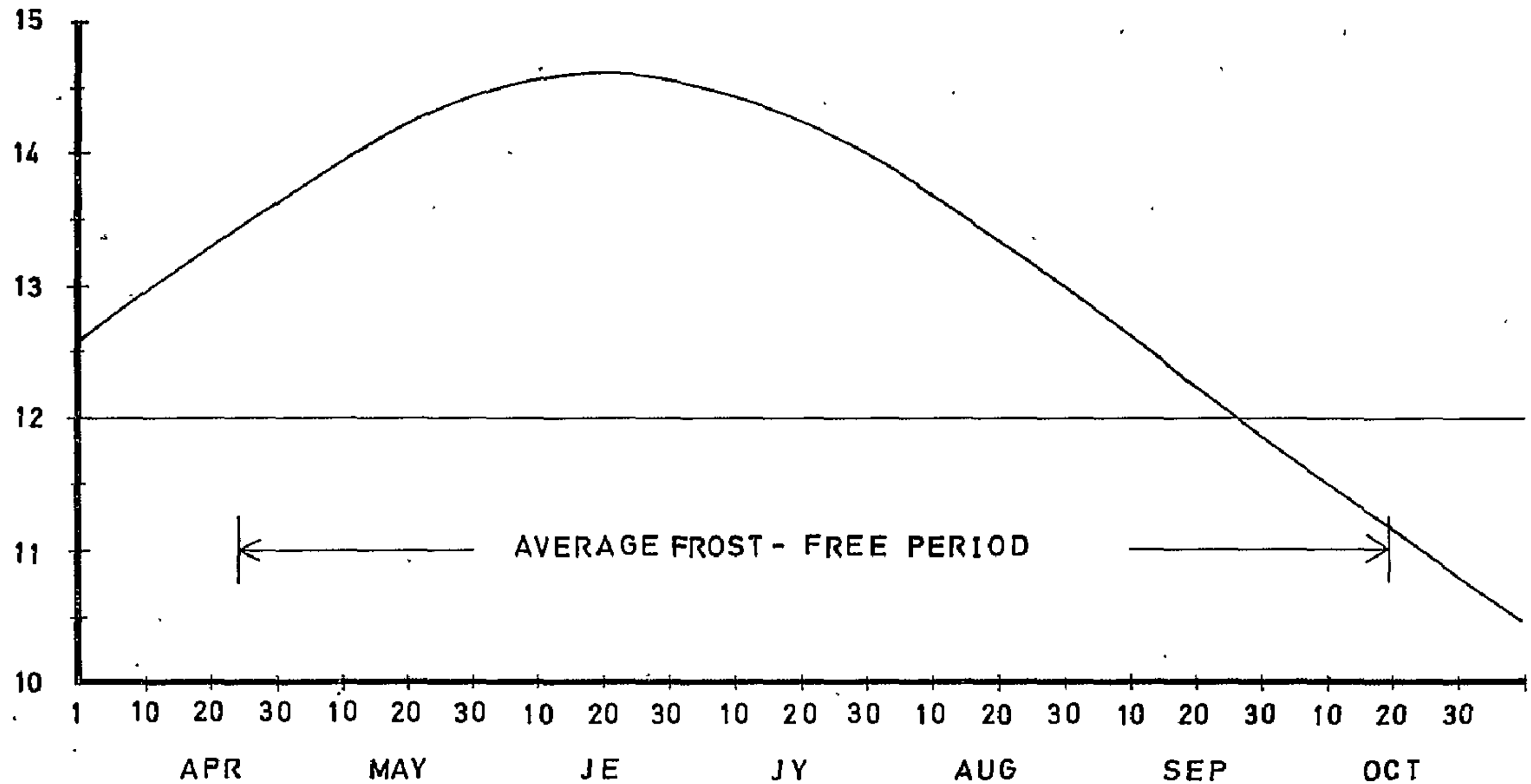
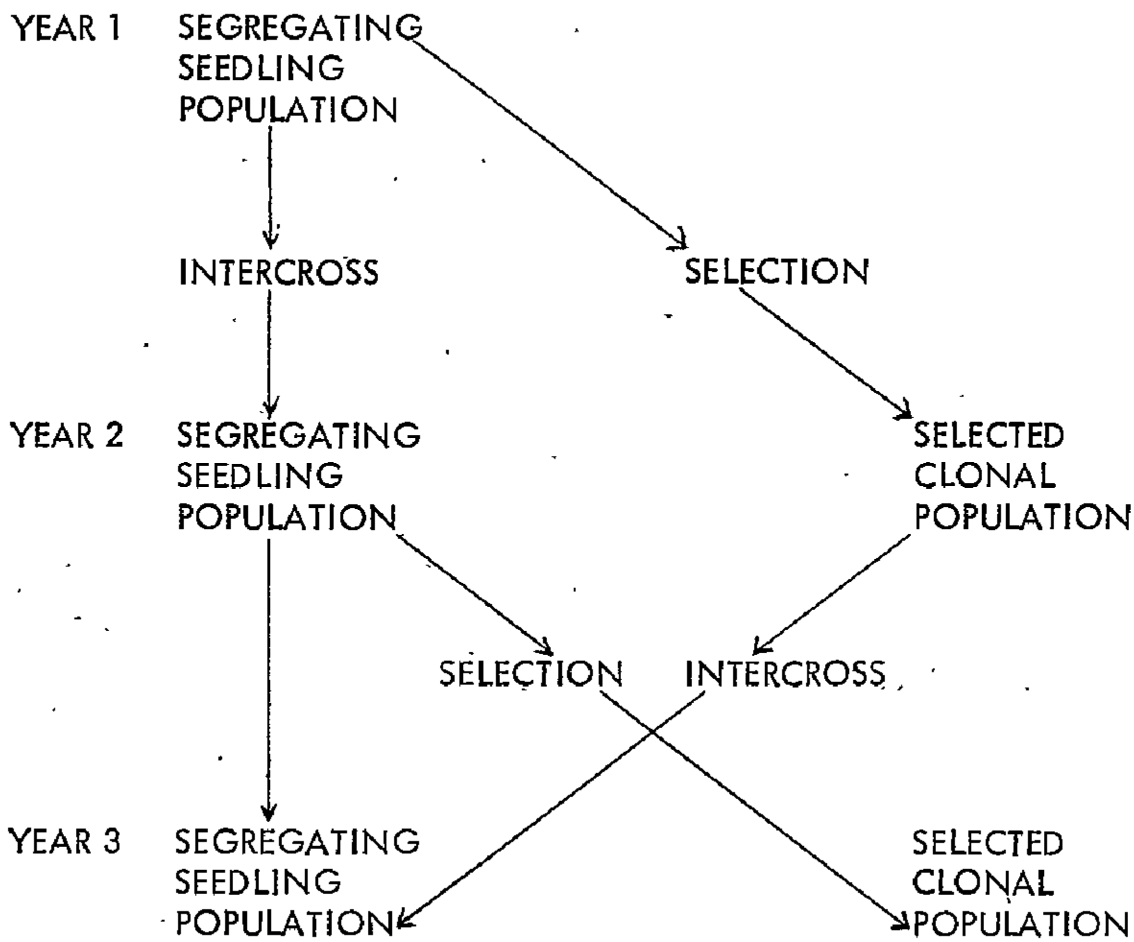


FIGURE 2.- HOURS FROM SUNRISE TO SUNSET FLETCHER, NORTH CAROLINA.
(DOES NOT INCLUDE TWILIGHT).

1. Mass selection. Under this scheme, two populations are grown each year after the first year according to the following plan.

MASS SELECTION SCHEME



ET CETERA

Pedigree records are maintained on a maternal parent or family basis sufficient to insure that a broad spectrum of families is included among the selected clones. Selection is made during the late summer primarily on the basis of responses to photoperiod, on vine type, and on response to infection by foliage diseases.

At harvest, selection is based initially on tuber production, size, smoothness, and shape. In advanced generations, internal tuber qualities will be added to these selection criteria.

2. Pedigree selection. From selected individuals within the clonal population, controlled crosses are being made. From these segregates, new selections and controlled crosses will be made each year.

Selection criteria are the same as for the mass selection scheme. Superior clones will be selected from populations produced in North Carolina from the three species S. ajanhuiri, S. phureja, and S. stenotomum. These will be tested in three widely different locations, two of which will be located in Peru. The Peruvian trials are being conducted in cooperation with Ing. Fermín de la Puente, leader of the National Potato Program of Peru. The trial locations are:

(1) North Carolina - temperate climate and both long and short day photoperiod.

(2) Mantaro Valley in the Sierra of Peru - short day, alpine condition.

(3) San Ramon in Peru - short day, tropical condition.

Portions of the basic populations have already been selected from a parallel project in North Carolina. Testing of early generations of selected materials will begin this year.

d) A study of the inheritance of response to photoperiod has been initiated. The availability of both long-day and short-day diploids allows the production of segregating populations which can be evaluated in the field in both North Carolina and Peru as well as under the closely controlled conditions provided by the Phytotron at Raleigh. An understanding of this phenomenon will become more important as the geographic range of the potato is extended and as more interspecific hybrids between long and short day types are exploited.

e) Crosses among selected derived diploids and between these diploids and selections from S. ajanhuiri, S. phureja, and S. stenotomum will be made. Segregates from these crosses will be studied for potential breeding value and promising clones utilized in the breeding program.

f) At intervals of two years, remnant seed of each population are being collected and stored. This seed stock will be sampled and planted periodically for comparison with advanced selections as a means of measuring progress.

Conclusions

As indicated, this program is in its infancy. Enough experience has been gained, however, and enough advancement has been made in selecting long-day types as well as improved tuber types among the diploids to assure that greater progress is possible.

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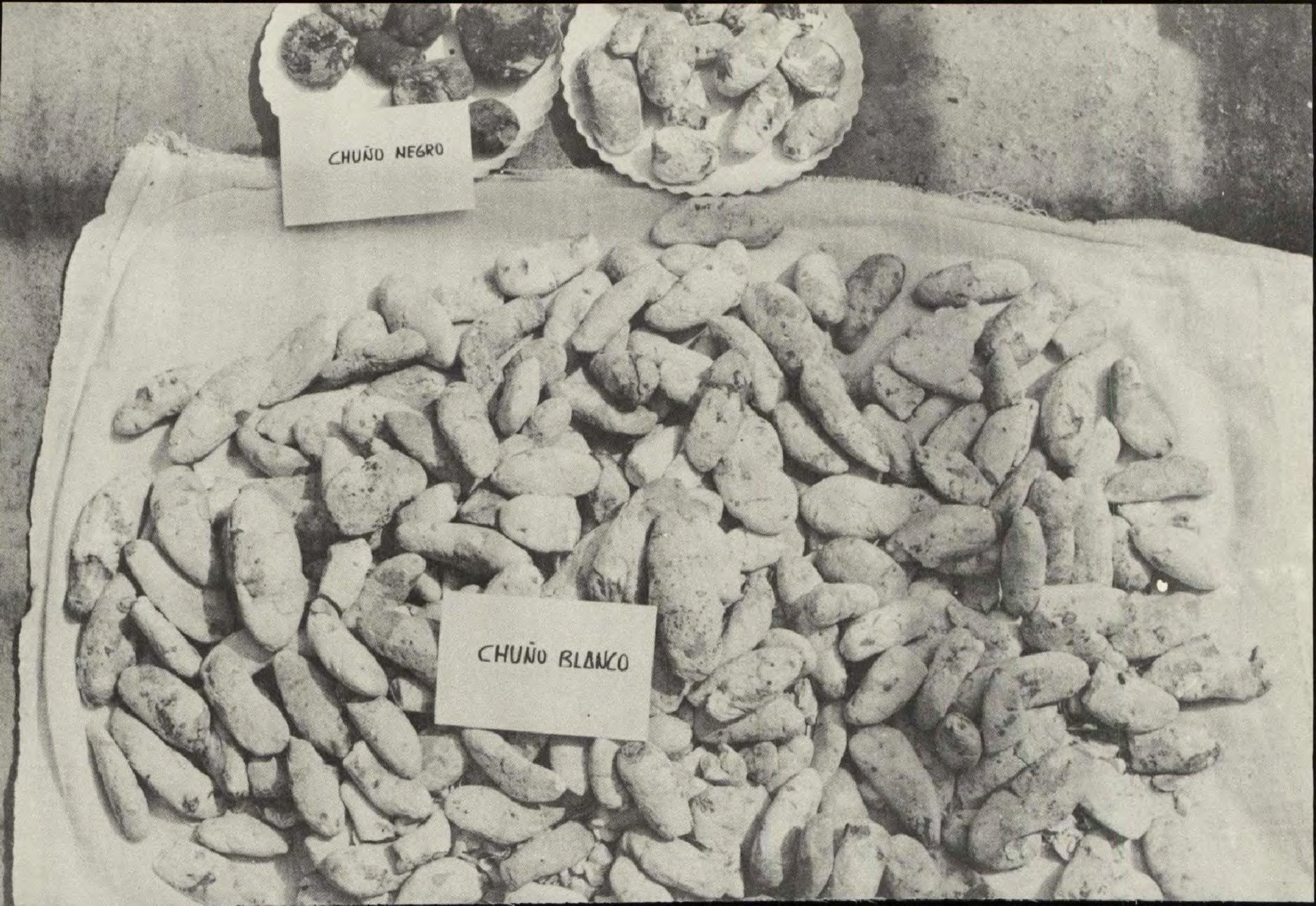
FOURTH SESSION

NUTRITIONAL QUALITY AND QUANTITY OF THE POTATO

Chairman, Jorge Christiansen
Head, Peruvian Yucca Program


CHUÑO NEGRO
CHUÑO BLANCO

NUEVOS USOS DE LA PAPA COMO ALIMENTO

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Hace muchos años que la civilización que nació en este país se ingenió para utilizar los recursos naturales que existían en la zona. La papa indudablemente fue una de las principales plantas que permitió crecer y desarrollar a una de las más prósperas y exitosas civilizaciones de la tierra. La papa conjuntamente con otros alimentos autóctonos, tales como la quinua (Chenopodium quinoa), se constituyeron en las materias primas fundamentales de la alimentación popular. Un alimento que por generaciones tiene a su cargo la base de la alimentación de un pueblo debe tener los elementos indispensables para el desarrollo de la vida. Este criterio fue indudablemente comprendido hace muchos siglos en el Perú y más tarde en otros países tales como Irlanda, Alemania, Rusia, donde la papa se constituyó en defensor de la alimentación popular.

El uso de este tubérculo ha ido gradualmente modificándose de la utilización directa del tubérculo por cocinamiento al de procesamiento por diversos métodos tecnológicos con el objeto de aumentar la conservación de este alimento y darle nuevos usos. Así, aparecen nuevas formas de utilización del tubérculo en forma de papa seca, chuño, papas fritas, harina de papa y mucho más tarde puré de papa instantáneo, Knödel, etc.

El consumo de este alimento fue expandiéndose en los países que estaban en proceso de desarrollo pero conforme ha ido pasando el tiempo y variando los hábitos alimentarios, el consumo de raíces y tubérculos en los países desarrollados ha ido disminuyendo en forma paulatina dando lugar a una mayor utilización de las calorías provenientes de las grasas. Fenómeno similar ha sucedido con el consumo de cereales. Pero en países donde el desarrollo aún es limitado el consumo de estos tubérculos no sólo no ha progresado sino que se ha estancado.

Significado del cultivo de papa en función de las necesidades nutricionales

Si hacemos una comparación de lo que los distintos países en proceso de desarrollo son capaces de producir para poder satisfacer sus necesidades nutricionales, podemos observar que en el caso concreto del área andina, la papa tiene numerosas ventajas como:

1. La cantidad de materia seca comestible por el hombre, que puede producir la papa por hectárea, es superior a lo que pueden producir otros cultivos. Una buena producción de papa puede significar 10 toneladas de materia seca por Ha., producción que no puede ser superada por cultivos de cereales.

2. La producción de papa puede ser facilmente expandida. Hay muchas tierras en la sierra que son aptas para este cultivo.

3. El perfeccionamiento del cultivo de papa ofrece actualmente la oportunidad de aumentar las fuentes de trabajo.

4. La variabilidad de los distintos clones de papa es muy grande tanto desde el punto de vista agronómico como de su composición química, propiedades físicas y organolépticas; ello indica que están prácticamente abiertas las posibilidades para producir alimentos de gran diversidad que contengan múltiples sabores, colores, texturas y valores nutricionales. Es labor del genetista, del tecnólogo y del nutricionista encontrar aquellas combinaciones que sean más favorables al país.

Pero habiendo todas estas ventajas cabría preguntarse cómo es posible que este cultivo hasta ahora no haya tenido un lugar más destacado en los países de la zona andina, que permita el autoabastecimiento alimentario en la región.

En nuestro entender son varias las razones:

1. La ausencia de procesos tecnológicos apropiados; ello no solamente debilita toda la producción e industria de la papa sino que limita su uso por falta de diversificación y de conveniencia para el consumidor.

2. La debilidad de la infraextructura de transporte, almacenamiento y comercialización de la papa frena la producción y consumo.

3. La ausencia de políticas de precios que estimulen la producción de alimentos, que pueden ser producidos adecuadamente por los países andinos.

4. Problemas de índole agronómico ligados a la calidad de la semilla, a la selección de las variedades y clones más apropiados, y pobres prácticas culturales limitan la producción económica.

5. La agresión cultural, económica y social del trigo importado. El hecho de que el trigo sea un producto que puede ser facilmente transportado a grandes distancias, que es fácil de manejar, de conservar, y que se puede importar a un precio inferior a su costo (por que existen enormes excedentes de trigo), ha motivado a que muchos países en el mundo se decidan a la importación del trigo, como una solución rápida a los problemas de autoabastecimiento de su población.

En muchos países ésto ha motivado el receso de la producción de algunos productos locales, entre lo que podemos contar en nuestro hemisferio al cultivo de la papa.

Nuevos productos elaborados a base de papa

Para aumentar el consumo de la papa hemos estudiado su utilización en alimentos elaborados tradicionalmente con trigo como son el pan y los fideos. Estos alimentos procesados que son tan agradables, económicos y atractivos, son los que han reducido el consumo de la papa hervida y horneada, del arroz cocido y en algunos casos hasta del maíz en forma de tortillas y arepas.

Teniendo en cuenta las investigaciones realizadas hace muchos años sobre la posibilidad de elaborar pan y fideos conteniendo papa es que hemos realizado un conjunto de investigaciones dentro del Departamento de Nutrición* que ha tenido como objeto producir: a) alimentos similares a los que se pueden hacer a base de trigo, y b) nuevos alimentos a base de papa. En ambos casos se pretende obtener ventajas de las propiedades de las distintas variedades y clones de papas disponibles así también como del buen potencial nutritivo que tienen estos tubérculos que en calidad proteica superan al trigo.

Valor nutricional de la papa

Es bien conocido el alto valor nutritivo de la papa en cuanto a su aporte calórico, de vitamina C, hierro, así como también por el alto valor

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* Auspiciadas por la Organización de Estados Americanos y por el Ministerio de Agricultura del Perú.

proteíco con buen balance de aminoácidos. Nuestras investigaciones señalan que en las papas peruanas estudiadas el contenido de materia seca varía desde 20% hasta 32.9%, mientras que el porcentaje de proteína fluctúa (sobre la base de materia seca) desde 4.7% hasta 15.3% (Cuadro 1). Existe considerable potencial para aumentar el contenido de proteína, como así también el de materia seca, de la papa.

Composición de los aminoácidos de la papa

Se realizaron estudios nutricionales de la proteína con harinas de papa de las variedades Renacimiento, Amarilla y Huayro, usando el nivel de 6% de proteína, que es el que nos pueden dar estas variedades, y se las comparó con caseína. La papa "Huayro" tuvo un PER ("protein equivalent ratio" o proporción equivalente proteica) de 2.74 que es más alto aún que el de la caseína que al 6% de proteína dió 2.27 (Cuadro 2). Estas proteínas son indudablemente de muy alto valor nutritivo, y deben de ser adecuadamente utilizadas a favor de la alimentación popular. Afortunadamente la proteína que contiene este alimento es de alta calidad, pero la cantidad en las variedades cultivadas es baja, pudiendo en el futuro ser aumentada considerablemente.

Estos estudios nutricionales tienen que ser perfeccionados, puesto que quedan por aclarar algunos aspectos relacionados con la velocidad de digestión de los gránulos de almidón de distintas variedades de papa; y porque hay necesidad de correlacionar los procesos tecnológicos de la papa con su valor nutritivo.

En cuanto a la composición de aminoácidos de las distintas variedades de papa hemos comenzado por analizar tubérculos producidos bajo condiciones estandarizadas tanto en la costa como en la sierra del Perú (en vista de los resultados obtenidos por U. Moreno con respecto a la variación de la composición de las papas según las distintas altitudes y latitudes).

En el Cuadro 3 se muestran algunos de los análisis de los aminoácidos de la papa y en la Figura 1 la variación de la composición de estas papas en función de la composición de la leche humana que ha sido tomada como línea básica de comparación. Algunas de estas papas tienen un valor nutricional que se aproxima al de la leche humana. La calidad nutricional aquí indicada ha sido confirmada por los buenos resultados que hemos obtenido en pruebas biológicas.

CUADRO 1.- Contenido de materia seca, y de proteína en base a materia seca (en porcentaje) de 59 variedades nativas de papas peruanas[1]

Variedad (y N°CPP)[2]	Materia Seca	Proteína	Variedad (y N°CPP)	Materia Seca	Proteína
Paltag negra (105)	30.188	11.096	Limeña negra (298)	22.884	10.792
Amarilla (431)	30.513	7.752	CPP-112A	28.963	9.348
Papa cocha negra (768)	21.296	12.160	Uracc paltag (9)	20.436	11.780
Castañeda (812)	28.917	15.352	CPP-451A	22.869	8.208
Lengua de vaca (560A)	29.800	9.956	Yuracc suito (47)	29.512	10.792
CPP-61	33.174	9.272	CPP-371A	25.110	10.108
Rayhuay (93)	29.194	12.920	CPP-256A	23.525	8.664
Sangualina morada (819)	22.748	12.008	CPP-641A	24.881	11.932
			Carmelita (459)	34.434	9.468
Puca ñahui (122)	25.680	7.600	Renacimiento (440)	28.108	9.424
Murinki (586)	26.204	10.792	Amarillo suito (244)	25.377	9.120
N°3 (375)	24.569	9.120	Chaclla huarmi (280)	21.234	5.320
Azul suitu (216)	26.521	10.260	Wachuywarmi (594)	36.371	9.956
CPP-572A	20.528	5.928	Manzana negra (232)	32.648	7.372
Elena (16)	24.261	14.592	Huaysash (697)	29.658	6.156
Yana Hualash (109)	21.847	11.552	Cabra matas (222)	31.715	9.446
Huiclus (31)	26.944	6.308	Chata colorada (408)	21.488	11.342
Yana Hualash (173)	28.203	9.804	N°8 (380)	24.520	10.336
Yana Hualash (418A)	26.589	10.860	Pillco (250)	22.999	9.120
Yana Hualash (413A)	20.740	8.749	Rosas suitu (227)	32.016	4.788
Puca Suichu (584)	26.768	9.272	Colhuan (448)	24.916	8.443
N° 18 (390)	28.508	10.479	Capiaj suitu (411)	26.822	9.176
Tumbash (87)	28.968	7.536	Púrpura blanca (461)	23.062	10.944
Manzana (213)	28.573	8.792	Buen cholo (650)	26.429	7.220
Bañosina (429)	29.103	6.471	Puca paratay (200)	26.912	5.776
Tarmeña colarada (6)	32.627	7.850	Chata (396)	25.297	6.764
Amarilla (286)	29.148	9.966	Usha papa (170)	25.360	11.020
Morales (265)	27.432	9.655	Jara allju (192)	26.720	7.752
Yana cupshro (152)	26.339	10.636	Cashphis (211)	27.780	9.196
Chata colorada (442)	26.144	6.829	Juan Domingo (600)	32.958	6.992

Promedio Materia Seca: 27.214%; Promedio Proteína: 9.288%

1) Obtenido de la Tesis de Cecilio Julián Granados Pérez

2) Entre paréntesis aparece el número correspondiente a la Colección Peruana de Papas (C.P.P.) de la Universidad Nacional Agraria.

CUADRO 2.- Evolución biológica a nivel de 6% de proteína[1)] en harina de las variedades de papa Renacimiento, Amarilla y Huayro, y caseína.

		Renacimiento	Amarilla	Caseína	Huayro
1.	Peso inicial g.	40.95	43.30	44.95	42.65
2.	Peso final g.	57.70	63.20	82.55	73.30
3.	Ganancia de peso g.	16.75	21.90	37.60	30.65
4.	Consumo de alimento por animal.	158.25	177.90	239.70	194.90
5.	Porcentaje de proteína en la dieta.	6.15	6.23	6.9	5.73
6.	Consumo de proteína por animal.	9.71	11.06	16.53	11.17
7.	P.E.R.	1.72	1.98	2.27	2.74
8.	Significación estadística Duncan 0.01				
	Duncan 0.05				

1) Todas las harinas provenían de papas peladas y cocinadas.

Elaboración de panes conteniendo papa

Estimulados por esta información se realizaron algunos estudios sobre la elaboración de pan conteniendo diversos niveles de puré de papa incorporado a la esponja de trigo. Después de algunas dificultades con respecto al manejo de la masa, a los tiempos de fermentación, al horneado, a los niveles de levadura, etc., se llegó a estandarizar un procedimiento de elaboración de pan de papa que permitió producir buenos panes conteniendo distintos niveles de sustitución de la harina de trigo por puré de papa. Sobre la base de sustitución de la materia seca del trigo se hicieron panes con 10, 15, 20, 25 y 30%

CUADRO 3.- Aminograma de las variedades de papa andigena Ccompis (nativa) y Varena (mejorada); andigena con tuberosum Mariva y Ticahuasi; y tuberosum Redskin, Grata, Greta y Desiree (gramos de aminoácido por 100 g. de nitrógeno).

Aminoácidos	Ccompis	Varena	Mariva	Ticahuasi
Lisina	33.77	52.78	39.96	41.88
Histidina	8.17	13.86	8.51	7.90
Arginina	21.02	35.27	24.87	27.33
Ac. Aspártico	111.59	175.53	97.19	100.64
Treonina	17.18	34.28	21.69	24.04
Serina	18.14	32.37	21.06	21.72
Acido Glutámico	92.34	164.02	102.40	127.64
Prolina	29.44	25.95	27.20	17.39
Glicina	19.88	32.97	19.77	21.72
Alanina	16.60	35.62	18.73	17.82
Valina	22.93	54.68	28.19	32.32
Metionina	6.15	20.60	6.19	5.05
Isoleucina	21.79	39.79	20.18	25.39
Leucina	31.11	51.17	34.62	40.63
Tirosina	21.50	27.49	14.69	23.42
Fenilalanina	23.37	38.90	23.75	29.68

Aminoácidos	Red skin	Grata	Greta	Desiree
Lisina	20.24	24.23	24.98	23.31
Histidina	6.59	6.57	5.96	6.64
Arginina	21.07	17.13	22.96	23.62
Acido Aspártico	25.96	111.09	116.21	118.48
Treonina	16.17	16.83	14.33	15.41
Serina	14.48	15.50	12.76	11.80
Acido glutámico	32.41	136.01	145.79	113.92
Prolina	11.50	13.77	11.93	11.40
Glicina	13.32	16.51	12.94	10.36
Alanina	16.14	16.04	14.37	13.23
Valina	24.72	21.73	21.49	23.12
Metionina	4.30	2.72	1.90	6.22
Isoleucina	16.53	18.25	13.80	15.93
Leucina	23.96	29.75	15.34	19.46
Tirosina	13.11	14.58	9.12	15.37
Fenilalanina	21.80	23.33	22.28	21.36

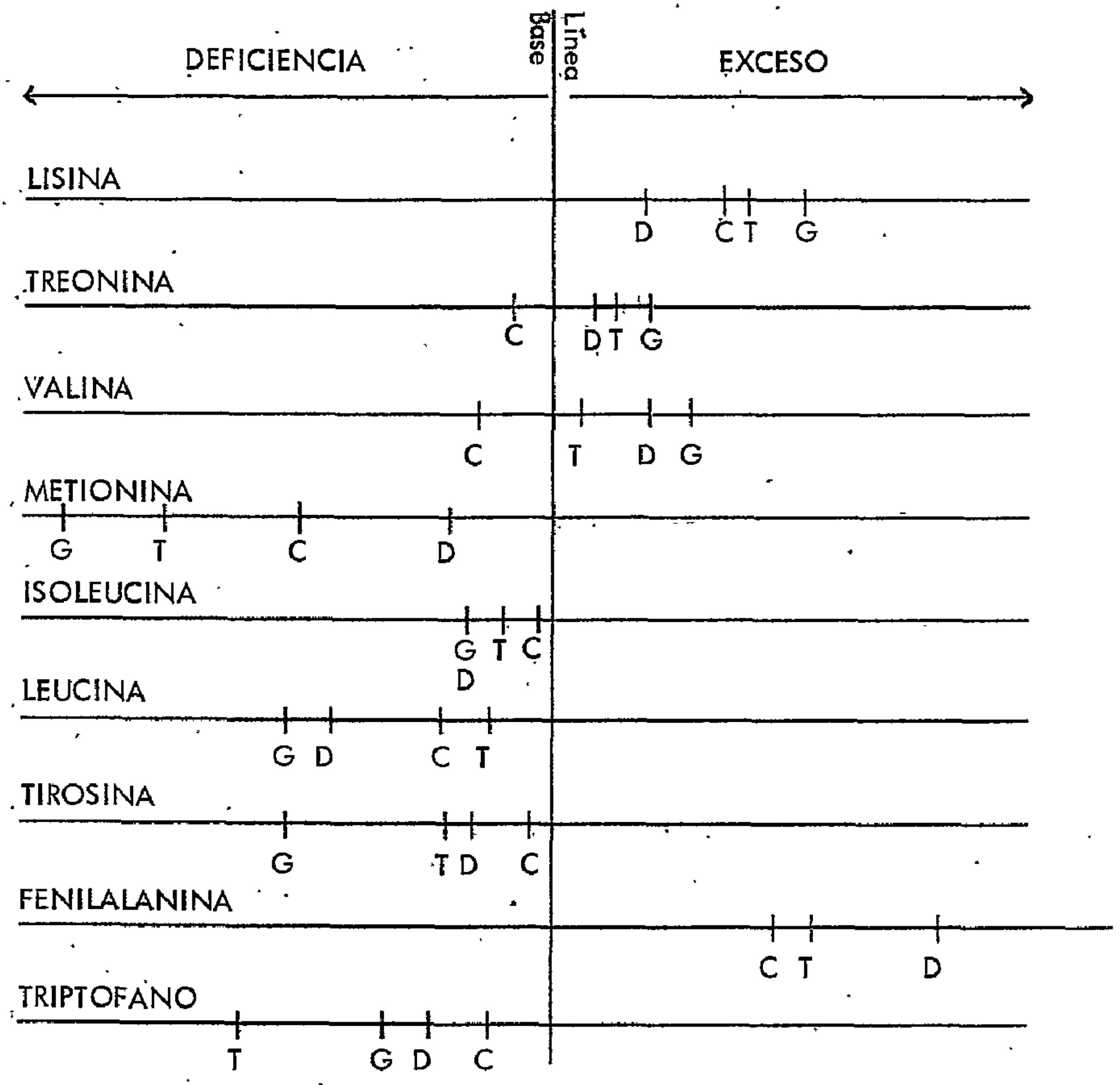

FIGURA 1. Contenido de algunos aminoácidos en relación a la leche humana (línea base) en cuatro variedades de papa (C = Ccompis; D = Desiree; G = Greta; T = Ticahuasi).

de sustitución por puré de papa. En otras experiencias se agregó además de papa una proteína de algodón denominada SH, para reforzar el contenido proteico de estos panes, a niveles de 7 y 10%. Las fórmulas de algunas de estas combinaciones se dan en el Cuadro 4, como así también las variaciones de tiempo necesario para cada paso del procedimiento. Nótese que hay solo un ligero aumento del tiempo necesario para algunos de los procedimientos. En cuanto a la evaluación desde el punto de vista organoléptico de los distintos panes, aquellos que contenían 25% o más de puré de papa fueron calificados como buenos, de 10 a 20% muy buenos, mientras que el pan de trigo recibió el calificativo de excelente. Los panes elaborados con puré de papa tenían las características para una buena aceptación en nuestro medio.

Los resultados que posteriormente se han logrado a través del trabajo de la panadería experimental en la Universidad Agraria, han demostrado que este producto es uno que tiene gran aceptación popular.

En cuanto al valor nutricional de estos distintos panes hechos con distintas proporciones de puré de papa de variedad Renacimiento (la cual predomina en el mercado limeño pero sin embargo no es la mejor desde el punto de vista nutricional) muestran resultados muy satisfactorios desde el punto de vista nutricional. Superan significativamente la eficiencia protéica del pan francés normal de la ciudad de Lima. La inclusión de proteínas de algodón eleva aún más el valor nutricional de dichos panes.

La conservación de los panes que contienen harina de papa es mucho mejor que los hechos sólo a base de trigo. Se mantienen "frescos" 5 a 6 días en las condiciones ambientales de Lima.

La experiencia lograda de producir este pan con papa durante 3 años en una panadería piloto nos ha indicado que el público está dispuesto a cambiar de hábitos en cuanto al consumo de pan, siempre y cuando el producto que se ofrezca sea de buena calidad. Sin embargo, otras realidades impiden recomendar al industrial la producción de este pan. Existen enormes fluctuaciones en los precios de la papa, y escasea en algunos meses del año. Pero si tuviera un precio justo y estabilizado, que garantizara la buena producción, y el progreso del buen agricultor (aquél que usa buena semilla, buenos fertilizantes, de aquél que trabaja bien y hace oportunamente las aplicaciones de insecticidas y fungicidas, etc.), podría asegurarse el desarrollo de un nuevo y mejor alimento y de una nueva pujante industria.

Esto no será posible mientras no exista una definición precisa en relación a la economía de la producción de la papa y se siga abusando del

CUADRO 4.- Fórmulas y procedimientos de algunos de los panes elaborados a nivel de directorio*

Ingredientes, peso en gramos		Pan de trigo	Pan-papa 10%	Pan-papa 20%	Pan-papa 30%	Pan-papa-25% -SH 10%
Harina de trigo		448	336	248	192	190
Papa sancochada (puré)	100	-	114	200	256	230
Harina de algodón SH		-	-	-	-	28
Levadura	1.34	6	6	6	6	6
Azúcar	2.00	9	9	9	9	9
Sal	1.24	5	5	5	5	5
Manteca	10.70	48	48	48	48	48
Agua		Variable	120	30	20	30

* Todas las substituciones son efectuadas en base a materia seca. Materia seca de la papa 28.5 y de la harina de trigo 90.

Procedimientos	Tiempo de los pasos de preparación tipo esponja (en minutos)				
- Tiempo de mezcla de la esponja-minutos	15'	15'	15'	15'	15'
- Fermentación de la esponja	30'	30'	30'	30'	30'
- Mezcla de todos los ingredientes	10'	10'	15'	20'	20'
- Primer punch	30'	30'	40'	50'	50'
- Fermentación 32°C	30'	30'	40'	50'	50'
- Segundo punch	30'	30'	40'	50'	50'
- Preparación de panes y fermentación	30'	30'	30'	30'	30'
- Horneado a 375°F (190°C)	20'	20'	20'	20'	20'

consumo de trigo importado, dificultándose así la defensa de los intereses de tanto el productor como el público consumidor. Se requiere el establecimiento de una política en relación a la papa que permita capitalizar sobre las potencialidades y avances realizados para obtener el máximo provecho de lo que el país puede hacer con sus propios recursos.

Elaboración de fideos conteniendo papa

La experiencia tecnológica, sociológica y nutricionalmente exitosa en la elaboración del pan nos llevó a estudiar las posibilidades de los fideos a base de papa. Los fideos fueron elaborados siguiendo las técnicas tradicionales, con las cuales se demostró que es posible elaborar a nivel experimental fideos de muy agradable sabor y buena aceptación.

En el Cuadro 5 se presentan las variaciones que han habido en cuanto al volumen, peso y porcentaje de sedimentación cuando los fideos con distintos porcentajes de papa son cocinados durante 20 minutos. La incorporación de papa hasta un porcentaje de 40% no resulta en cambios demasiado importantes, y éstos son menos drásticos cuando se incorpora solamente 10 a 20% de harina de papa.

Desde el punto de vista nutricional en pruebas biológicas la incorporación de papa Yungay resultó en ritmos de crecimiento progresivamente menores en grado ligero y en eficiencias también un poco más bajas que el fideo de trigo, con cada aumento respectivo. Para contrarrestar este efecto

CUADRO 5.- Datos de una prueba de cocción de 20 minutos de duración para 100 g. de fideos tipo canuto conteniendo distintos porcenjes de papa.

Porcentaje de Papa	Volumen inicial	Volumen final	Peso final (g)	Sedimentación (CC)
10%	75	278	305	10
20%	73	260	285	20
30%	79	255	280	28
40%	75	290	320	32
50%	79	280	280	89
60%	71	287	320	15

se agregaron pequeñas dosis de proteínas aisladas provenientes del pescado. El valor biológico de estos fideos se elevó notablemente con la sola incorporación de 4% de esta proteína. La calidad del fideo conteniendo trigo, papa y pescado fue extraordinariamente buena sin que hubiesen problemas relativos al sabor del producto.

Otros productos

Los buenos resultados logrados tanto en pan como en fideos nos permiten preveer la necesidad de elaborar otros productos nuevos a base de papa como por ejemplo, alimentos para desayunos, hojuelas, carapulcras, snacks, y tortillas de variados sabores y texturas.

Indudablemente que también hay muchos alimentos que ya son conocidos, que pueden ser mejorados a base de la conjugación de la papa con concentrados o alimentos protéicos que eleven la cantidad de proteínas del producto. Como ejemplo tenemos al pizza-pan, hecho con papa, filetes de pescado y trigo, que tiene muy buena aceptación.

En todas estas posibilidades tienen que combinarse los factores agronómicos, económicos, genéticos, organolépticos, nutricionales y tecnológicos de los distintos productos incluyendo la facilidad que puedan tener distintas papas para su procesamiento.

No parece haber ninguna limitación en cuanto al rol que pueda cumplir la papa en función de la producción de alimentos nuevos, tales como bebidas, productos texturizados que imiten a la carne, y toda la generación de productos que han sido producidos en otras partes a base de alimentos que fueron tan poco prometedores como la soya. La papa por su propia característica, por el hecho de haber sido un producto aceptado para el consumo humano desde hace muchísimos años, ofrece posibilidades extraordinarias que deben de ser plenamente utilizadas.

En países donde las condiciones ecológicas son mas favorables a la producción de la papa que la del trigo, se debe analizar el rol futuro de la papa como alimento básico, no solo para el agricultor que subsiste en base a este cultivo, sino para las poblaciones urbanas, haciendo preguntas relativas al desarrollo económico-social-cultural.

La papa ha sido y es la base de la cultura en varios países andinos, y seguirá siendo uno de los cultivos alimenticios del cual se tendrá que depender para el desarrollo autosostenido de sus pueblos.

BREEDING FOR IMPROVED TUBER PROTEIN CONTENT AND QUALITY

Sharon L. Desborough & C.J. Weiser
(presented by D.G. Richardson)
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The subject of this presentation is in the process of being published (1). Therefore, only the following brief summary should be published in the proceedings of this Symposium.

The quantity and quality of tuber protein has been investigated in selected Phureja-Haploid Tuberosum families. Six families have been grown for two years at two locations. These families include diploid and tetraploid progenies. There is an effect of ploidy level and growing location on the amounts of tuber protein. We have found by selecting parents high in protein that the average protein content of their progeny can be doubled and in some genotypes tripled. More important the nutritional value of the protein is improved as measured by gains in essential amino acids.

This current year the studies have been expanded to include the relationship between nitrogen content and total protein. Also comparisons have been made between the relative amounts of sixteen amino acids, the total amino acid content and the total tuber protein. Information has been obtained about the free amino acid pool and the amino acid content of the tuber protein. It appears that relative amounts of the sixteen amino acids remain high in genotypes selected for high protein. Preliminary flavor analyses suggest that there is no adverse effect of high protein on taste of the cooked potato. Other studies have been conducted on the relation of fresh tuber weight to amount of tuber protein. Further research concerning the heritability of essential amino acids and total tuber protein are underway.

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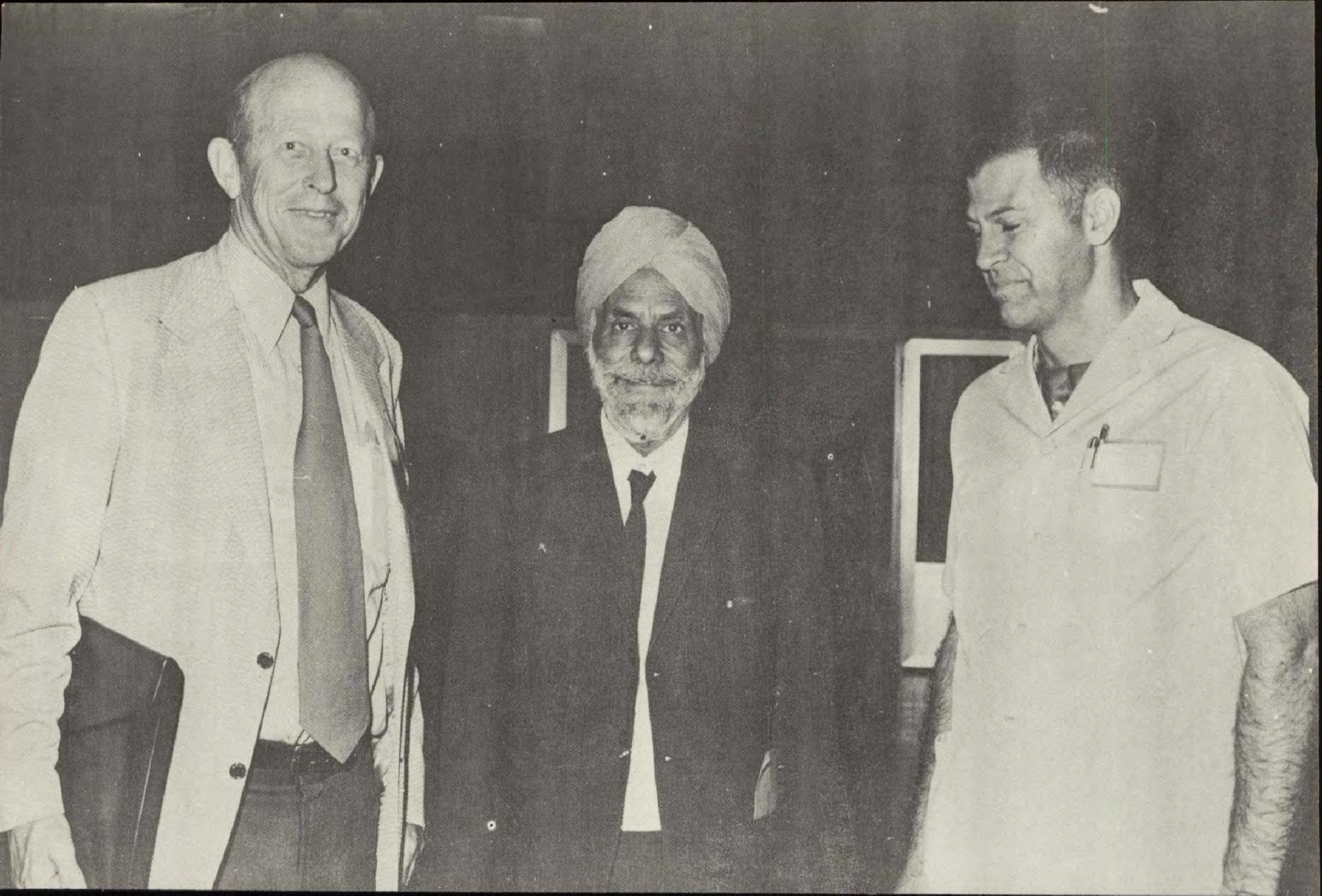

FIFTH SESSION

LATE BLIGHT RESISTANCE

Chairman, John Niederhauser
Director of CIP's Outreach Program

POTATO BREEDING FOR EAST AFRICA

W. Black (presented by D.C. Harris)
British Potato Research Team, Nairobi, Kenya

The purpose of this paper is to discuss the prospects of establishing the potato as a major food crop in E. Africa. The potato was first introduced into East Africa from Europe early this century but it made relatively little progress because the varieties were not specially adapted to tropical conditions, namely short day length, intense light, and high temperatures.

Potatoes originated in the tropics, in the Andes of Bolivia and Peru. The history of the potato (Dodds 1965, Hawkes 1967) shows that the common potato, Solanum tuberosum, which is tetraploid (2n = 48 chromosomes) originated from diploid ancestors (2n = 24 chromosomes). Accordingly, we have a complex of diploid types grown for food in South America, but only on a limited scale, together with a complex of autotetraploid types which are more widely grown. It was the latter which provided the material for the development of the crop in temperate latitutes over the past few centuries.

Potatoes first found their way to Europe late in the 16th Century, but they proved to be poorly adapted to the climatic conditions. Little improvement in productivity was made until the 19th Century when better types were gradually developed by breeding methods. The improvement has been rapidly accelerated in the present century and the potato has become, through constructive breeding, a major food crop in most of the temperate regions of the world. Thus a tropical plant from South America has been successfully adapted by breeding methods to temperate regions, and we are now trying to take it back to the tropics but to a different continent. If success is to be achieved in minimum time, advantage must be taken of improvements in commercial qualities and in disease resistance, effected over the years in temperate countries, and these must be combined with factors controlling adaptation to short day conditions and higher temperatures. It would appear that this problem may not be so difficult to solve as might be expected. If a breeding programme is limited to pure S. tuberosum derivatives, such as many of the cultivars grown in temperate countries, then the chances of obtaining types suitable

for short day conditions are rather remote. The genes controlling adaptability to tropical day length have been largely bred out. But modern plant breeding programmes particularly those involving disease resistance, include not only wild species but selections produced under tropical and subtropical conditions. Such breeding material has every chance of contributing genes for short day conditions and higher temperatures and of providing a wider range of types for selection purposes. It has been found that the later maturing types selected under temperate conditions tend to give the better results in the tropics, and late maturity has, therefore, been an important factor in selecting for the tropics. Presumably some linkage exists between factors for late maturity under temperate conditions and factors for adaptation to short day conditions. The problem of breeding for the tropics in temperate countries is, therefore, quite feasible, but, of course, the ultimate selection trials must be carried out under short day conditions and in the environment where it is proposed to establish the crop. This relationship between time to maturity and day length has been clearly shown by Pushkarnath (1970).

Apart from adaptation to tropical conditions and the improvement of yield and other desirable commercial qualities, the problem of disease resistance must be considered in any breeding programme. Disease epidemics have been, throughout history, a major threat to man's food supply. Despite the advances made in chemical methods of disease control, the use of resistant varieties of crop plants represents the most economical means of defence against some of the more destructive pathogenes like cereal rusts, apple scab, potato blight and potato root eelworm. The potato crop may be attacked by many different organisms - viruses, bacteria, fungi, nematodes and insects. They are all important from the point of view of epidemic risk, but fungi probably occupy first place in East Africa, with bacteria second.

In potatoes, the ability to resist disease is controlled by two different genetic systems. One of them, "hypersensitivity", is controlled by major genes, but is valuable only against pathogenes of low variability such as viruses X, A, B and C. In hypersensitive plants the cells are so sensitive to the invading organism that those near the point of entry are rapidly killed and form a necrotic barrier to further penetration. The parasite is thus imprisoned in local necrotic lesions and is unable to survive. This form of resistance was originally employed in the control of blight (Phytophthora infestans) but this fungus proved to be extremely variable, and new races capable of overcoming the different hypersensitive forms that were bred, appeared within a few years. Thus, the strain-specific form of resistance proved to be of temporary value only. To overcome this difficulty breeding-work was concentrated on the other form of resistance viz. general or field resistance.

Field resistance may be described as the degree of resistance exhibited by a plant to all races of the parasite. It is inherited in polygenic fashion and the various minor genes involved appear to supplement each other in the control of the disease. In individual plants these minor genes determine:

(1) the degree of resistance to infection

(2) the rate of spread after infection

(3) the time required for sporulation to begin

(4) the number of spores produced

The combined effect of all these different factors determines the degree of resistance present in plants. Seedlings tested under controlled conditions may, therefore, be classified with a reasonable degree of accuracy into five resistance groups according to the amount of damage incurred seven days after inoculation. In that time the group 5 seedlings are completely blighted. The reaction groups are described in Table 1.

TABLE 1.- Classification of field resistance

Reaction group	Type of lesion	Estimated area affected (%)	Description
1	Restricted	3	Highly resistant
2	Partly arrested	10	Fairly resistant
3	Retarded	30	Slightly resistant
4	Normally progressive	60	Normally susceptible
5	Rapidly progressive	100	Very susceptible

Note: In the Tables that follow, the signs + and - are used to describe more exactly the resistance of the parent plants; e.g. a 3+ reaction indicates that the plant is on the susceptible side of the group 3 range while a 3- reaction is on the resistant side of that range.

This test for field resistance to blight has been employed both in Scotland and in Kenya with comparable results. The present work is, in effect, a continuation of the investigations on the nature and inheritance of field resistance previously published (Black 1970) but, of course, the emphasis is now on the selection of blight resistant types adapted to short day conditions.

The work now in progress includes the hybridisation of blight resistant selections of near commercial standard in order to build up resistance to a high degree in the background of desirable economic qualities. It can be seen (Table 2) that group 1 and group 2 seedlings may be obtained in satisfactory proportions even when one of the parents reacts as group 3. The culture of blight employed reacted as race 1, 2, 3, 4, 7.

TABLE 2.- Blight resistance in hybrid progenies.

Ref. N°	Parentage	Reaction of parents	N° of Seedlings tested	Distribution of seedlings (%) in reaction groups				
				1	2	3	4	5
7530	4253ab(25)xP. Ivory	1+x4-	202	4	16	33	29	18
8671	5666ab(4)x3071ab(1)	1x2+	210	10	6	22	38	24
7676bc	4519a(3)x4495ac(11)	3x1	222	8	13	13	45	21
8683c	6062ab(5)x6300-2(4)	1+x2-	121	16	7	28	36	13
7471a	R. Castlex5389(2)	3x1	145	17	12	32	33	6
7535a	4254bc(21)x4495ac(11)	3x1	159	12	22	19	36	11
7115a	4517(1)x3869ad(7)	1x3	167	12	24	25	35	4
8622	4519a(2)x6372a(3)	3x1+	166	10	31	20	25	14

When both parents are group 1 types (Table 3) the proportions of group 1 and group 2 seedlings are generally much higher, depending, of course, upon the extent to which the two parental contributions supplement each other towards maximum resistance. The combined proportions of group 1 and group 2 seedlings may reach 70% in some progenies and since these plants do not usually require protective spraying the proportion of resistant survivors available for selection for commercial qualities in general is satisfactorily high.

TABLE 3.- Blight resistance in hybrid progenies

				Distribution of seedlings (%) in reaction groups				
Ref. N°	Parentage	Reaction of Parents	N° of Seedlings tested	1	2	3	4	5
7652b	4514a(3) x4495ac(11)	1+x1	100	11	15	24	34	16
7637ab	4495ac(5)x5389(2)	1+x1	164	17	18	23	31	11
8711	6456ab(52)x6372a(3)	1x1+	80	31	19	15	19	16
8673a	5666ab(4)x6372a(3)	1x1+	125	22	46	14	10	8
8597b	4517(1)x6000ab(33)	1x1+	131	17	56	15	10	2
7667	4517(1)x4495ac(11)	1x1	80	18	22	33	22	5
7702ab	5389(2)x5567c(6)	1x1	200	23	29	15	26	7
7513	3681ad(1)x4495ac(11)	1x1	137	36	33	16	12	3
8601a	4517(1)x6456ab(4)	1x1	180	28	41	23	6	2

In East Africa the most destructive disease of potatoes is blight and a breeding programme has been established to deal with it. A collection of late maturing blight resistant seedlings bred in Scotland and selected during the past 8 years has been introduced and its value is being assessed. In addition, a collection of hybrid seeds produced in Scotland and known to possess the necessary blight resistance is being employed to provide a range of material for selection purposes. It is expected that these selections will serve as the basis for further constructive breeding work and may even give a few types of immediate commercial value in Kenya.

My interest in potatoes for the tropics started with a visit to East Africa in 1949 and continued with the submission of late maturing selections for trial in Kenya by Dr. R. M. Nattrass. Over the next few years five of the selections were named and introduced into commerce. Some of them are still grown, and one introduced in 1953, named Roslin Eburu, is believed at present to occupy most of the potato acreage in East Africa. Although its field resistance to blight is only moderate, the degree of resistance it does possess together with its adaptation to short day conditions and its cropping propensity, has established it over a wide area. Its family tree (Fig.1) shows that both

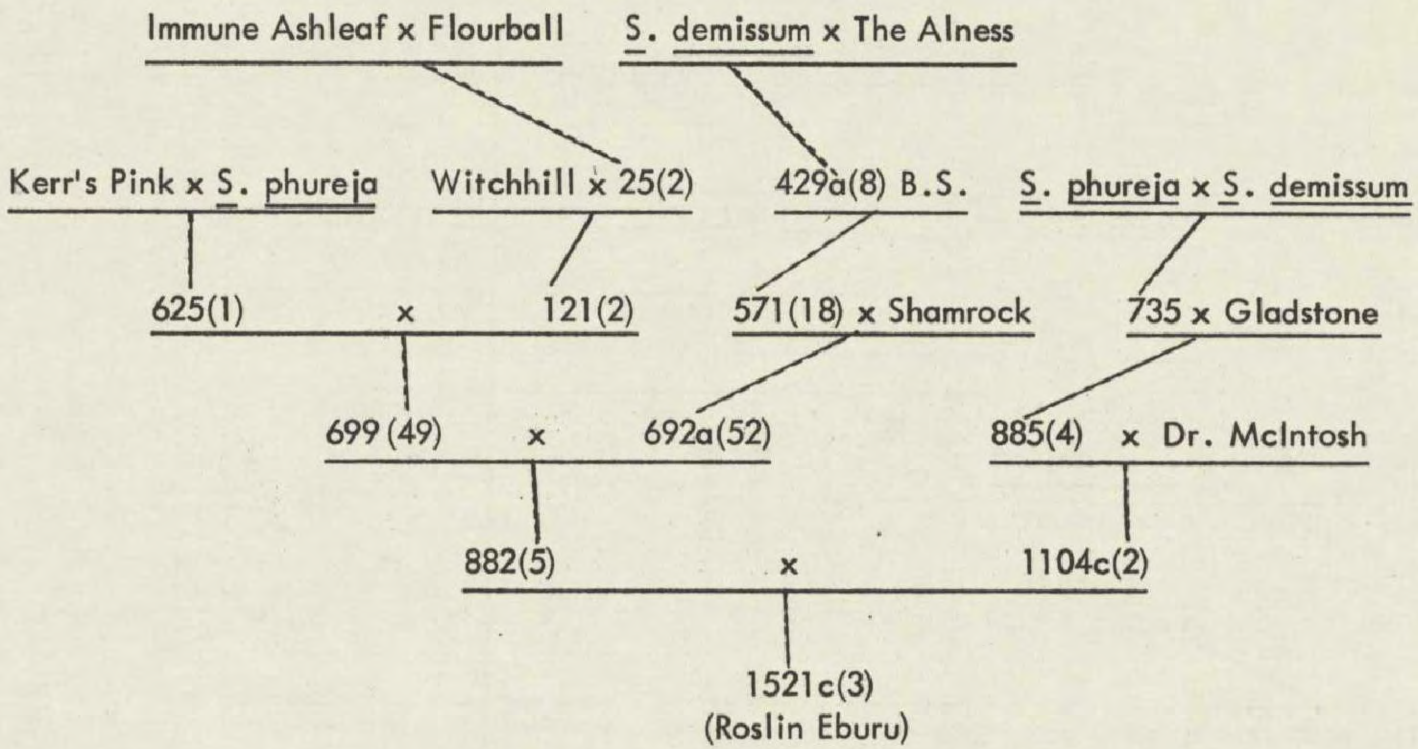

FIG. 1.- Pedigree of Roslin Eburu

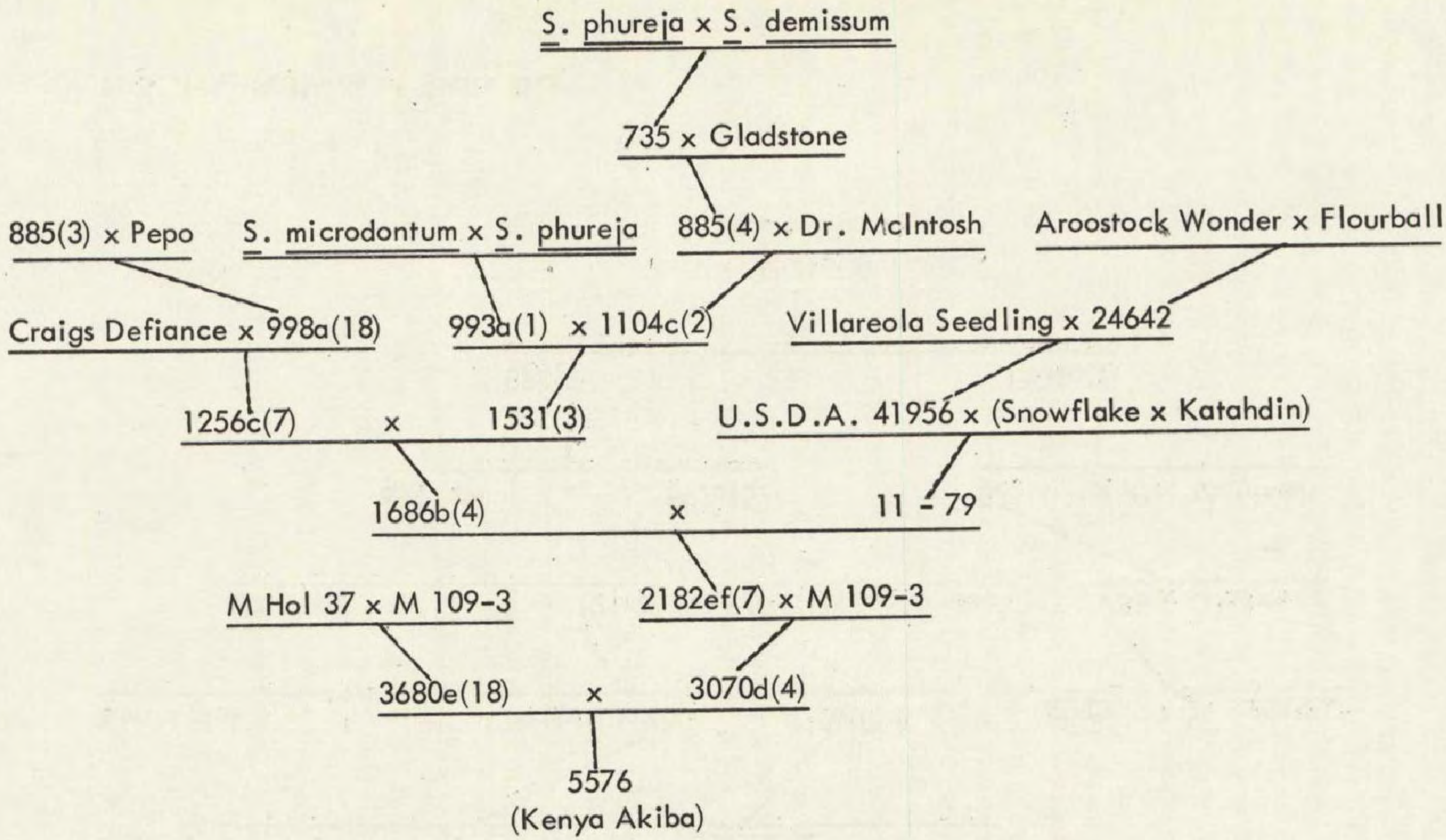

FIG. 2.- Pedigree of Kenya Akiba

S. demissum and S. phureja are twice represented in its parentage, as well as 8 commerical varieties known in Britain.

In 1962 a request was received from R. A. Robinson, then Senior Plant Pathologist, for hybrid seeds to sow in Kenya and to screen the resulting seedlings for resistance to blight and bacterial wilt. Some promising selections were obtained from this source and one of them, named Kenya Akiba, has been released into commerce. Another seedling of the same parentage is at present undergoing regional trials and, if it reaches the desired standard, it will also be named and released. The origin of these selections is shown in Fig. 2.

The family tree of Kenya Akiba shows that S. demissum and S. microdontum are represented once and S. phureja twice. The commercial varieties employed include American, Australian and German as well as British cultivars while two blight resistant selections obtained from Mexico play a prominent part in the later breeding. It is thus very much international in origin. Kenya Akiba has much better blight resistance than Roslin Eburu and has shown also some resistance to bacterial wilt.

It is proposed to establish in Kenya a comprehensive potato breeding programme to cover the more important qualities necessary for the improvement of the crop. The material referred to above will form the basis of that programme.

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RECENT RESEARCH ON PHYTOPHTHORA INFESTANS IN EAST AFRICA AND THE DEVELOPMENT OF LATE BLIGHT RESISTANT POTATO VARIETIES FOR THE HIGH ELEVATION TROPICS

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Potatoes, Solanum tuberosum, are grown almost throughout Uganda, but are particularly well adapted in the areas of higher elevation in Kigezi, in southwestern Uganda, and in the mountainous areas of Bugisu and Sebei, near the border with Kenya. At one time the estimated potato acreage in Uganda was more than 17,000 acres. However, during the past ten years the acreage devoted to potatoes has greatly decreased because of very low yields and the lack of a reliable source of seed resulting in increased imports of potatoes in Uganda (11). Even in the higher elevations of Kigezi, the major potato growing area of Uganda, yields are commonly as low as one to two tons per acre. The low yields have been attributed to a number of factors including the lack of suitable varieties, a low standard of management and disease problems. A number of diseases including bacterial wilt (Pseudomonas solanacearum), Cercospora leaf spot (Cercospora concors) and several virus diseases greatly reduce yields. However, the late blight disease caused by Phytophthora infestans is the most serious factor limiting potato production in Uganda, since the disease can quickly reach epiphytotic proportions wherever potatoes are grown (12). Numerous potato varieties have been brought into Uganda, mostly from neighboring Kenya, in an attempt to find resistance to late blight. Such varieties as Kerr's Pink, Dutch Robijn, and more recently, Roselin Eburu were grown widely in Uganda but seemed to become susceptible to late blight (5). Whereas in Kenya, blight susceptible potato varieties can be grown commercially with the aid of fungicides, the entire crop in Uganda is produced by subsistence cultivators who cannot afford chemical control measures.

Literature Review

Gallegly (5) conducted a survey of problems involved in potato improvement in Uganda and concluded that late blight was the main factor

responsible for low yields in Uganda. He recommended that (i) breeding for late blight resistance should be given priority along with the development of a certified seed program; (ii) a survey of the pathogenic races of Phytophthora infestans be conducted so breeders would know what type of resistance to incorporate in new varieties; and (iii) the main emphasis in developing blight-resistant potato varieties should be placed on the use of the multiple-genic type of resistance to insure resistance stability. Black (2) defines field resistance as the degree of resistance exhibited by a plant to all races of the fungus to which it is not hypersensitive. Niederhauser (10) has reported that the protection by field resistance remained unchanged in the Toluca Valley, in Mexico over a period of ten years. Black (2) notes that the variety, Roslin Eburu, which exhibits a field resistance rated at 2+, is well adapted to the short day conditions of East Africa where it has been grown commercially for over ten years. However, Wurster (11) reported that some varieties of known resistance to late blight, including Roslin Eburu, were severely attacked in Kigezi during growing seasons favorable for the development of the disease. Gallegly (4) noted that the disappointing search for stable resistance to late blight has resulted mostly from the extreme pathogenic variability of Phytophthora infestans. These factors point to the need of careful assessment of the resistance of potato varieties before their release for general use by subsistance farmers.

Methods

a) Identification of races of Phytophthora infestans: The method used for identifying races of P. infestans is based on the work of Black (1). The following derivatives of Solanum demissum were obtained from the Scotish Plant Breeding Station, Pentlandfield, for inoculation with isolates of the pathogene collected in Uganda and Kenya: Single dominant gene series $R_1 - R_{10}$, including the recessive (rr) and multiple genotypes R_1R_2, R_1R_3, R_1R_4, R_2R_3, R_2R_4, R_3R_4, $R_1R_2R_3$, $R_1R_2R_4$, $R_1R_3R_4$, $R_2R_3R_4$, $R_1R_2R_3R_4$. The plants were grown in an insect-free enclosure until they had an average of six to eight mature leaves for inoculation by the detached leaf technique (8). Isolates of the pathogene were collected from major potato growing areas of Uganda and Kenya and maintained according to the in vivo method described by Keay (7) and modified by Kori (8). The technique involves the insertion of a disease leaflet with a young, active lesion into a deep cut made in a tuber, usually taken from the same plant. The tuber containing the diseased leaflet is held together with a rubber band to avoid dessication and stored in a thermostatically controlled refrigerator at 13°C. until needed for inoculation. Every six weeks, the fungus was transferred into healthy tubers of

variety Alpha, which contains no R-genes for resistance to late blight. Inoculum was prepared by asceptically cutting small slices of a blighted tuber which were placed on moistened filter paper in petri dishes held at 18°C in a low-temperature incubator. In this environment abundant sporulation was obtained within four to five days. Zoospore release was achieved by placing the sporangia harvested from the above procedure in distilled water at 13°C for 30 minutes to one hour. Inoculations were made by placing small cotton balls soaked in the zoospore suspension on the leaflets to be tested. The entire method was modified slightly to employ whole leaves which were kept turgid by immersing the petioles in 100 ml flasks containing distilled water and held for four to five days in an incubation chamber as described by Hunt (6). A key similar to that employed by Black (2) was used to read the reaction of the differentials, but sporulation was used as the main criterion for susceptibility.

b) Assessment of blight resistance in some East African potato varieties: Before the introduction of any new germ plasm was begun, a collection was made of local and existing varieties within East Africa (Table 3). A number of clones grown locally in Uganda, which could not be identified by varietal name, were obtained from the Kawanda Research Station, Kampala, and listed according to their station acquisition number. Roslin Eburu (B-53) and Kenya Akiba (RW-2) were obtained from the National Agricultural Laboratories, Nairobi. In some cases where only two or three tubers of a variety were collected, the tubers were sprouted in sterile vermiculite and multiplied by the use of individual sprouts or stem cuttings. Ten tubers of each variety were planted at two locations, Kabanyolo University Farm (elevation 1463 meters) and Kabale (elevation 2195 meters). One row of the blight susceptible variety, Alpha, was planted between every two rows of the local varieties being assessed for blight resistance. No inoculation was used in the field trials and no pesticides were used except Rogor 40 (dimethoate) to control aphids. The plants were rated biweekly according to an internationally accepted disease index used for rating the foliage for resistance to late blight (see footnote in Table 3).

c) Introduction and testing of new germ plasm: True seed from crosses of known blight resistance were imported from the U.S. Department of Agriculture, Beltsville, Maryland. The seed was germinated on filter papers in a germinator (Baird and Tatlock, Ltd., London) and held there for four to five days or until a radicle 1 to 2 cm long was produced. The seedlings were then individually transferred with a flattened dissecting needle to 8 x 10 cm polyethylene bags containing sterilized soil and grown in a screened enclosure (Figure 1). After the plants had matured, usually in about 70 to 90 days, the marble-sized tubers were harvested and stored until dormancy was broken.

The sprouted tubers of each family line were planted individually at a spacing of 90 x 60 cm at test plots at the District Farm Institute, Kigezi (elevation 2195 meters). The land chosen had been under grass for over 30 years and the site selected was a hilltop making contamination with soil-borne pathogens, such as Pseudomonas solanacearum, through drainage water unlikely. The land was prepared with ox-drawn implements and Thimet was applied as a systemic soil insecticide before planting. Aldrin (40%) was also used to control cutworms and other soil insects which became a problem during the growing season. As described above, rows of a blight susceptible variety were interspaced with the rows of plants being assessed for resistance to late blight and no inoculation was used. The foliage was also rated biweekly for resistance to late blight and plants showing a high degree of resistance were marked during the growing season and re-examined at harvest when data was recorded on the yield and tuber characteristics of resistant plants. Tubers from lines selected during the first season were planted in the field and again exposed to late blight to eliminate "escapes" from the first season. Selections were made on the basis of acceptable tuber characteristics from plants having a blight index of 2+ or better and sent to the Rockefeller Foundation International Potato Program in Mexico for further testing.

Results

The races of Phytophthora infestans identified from isolates collected in Uganda and Kenya are listed in Table 1. In addition to confirming the existence of races of P. infestans already reported in Kenya (3) nine additional races were identified by 1971 (8). In all, at least 15 races of P. infestans are now known to occur in East Africa on potato in addition to three on tomato and at least two on other solanaceous hosts. The greatest number of races from one region were identified from isolates collected from Kigezi. The most common race identified from all isolates collected was race 4, representing almost 20 per cent of the total isolates collected (Table 2). More than half of all isolates collected from Uganda and Kenya belonged to races 4; 2,3; 3,4; and 1,2,3,4.

The mean blight indices of some local potato varieties tested at two locations in Uganda are presented in Table 3. During the first growing season, the attack by late blight was generally more severe on the plants grown at Kabale than on the same varieties grown at Kabanyolo, but some clones survived at both locations. After the third growing season at Kabale, all clones were discarded on the basis of susceptibility except B-53 (Roslin Eburu) and RW-2 (Kenya Akiba). Roslin Eburu has consistantly received a blight rating of 3+ for late blight over a four-year period in Kigezi. Kenya

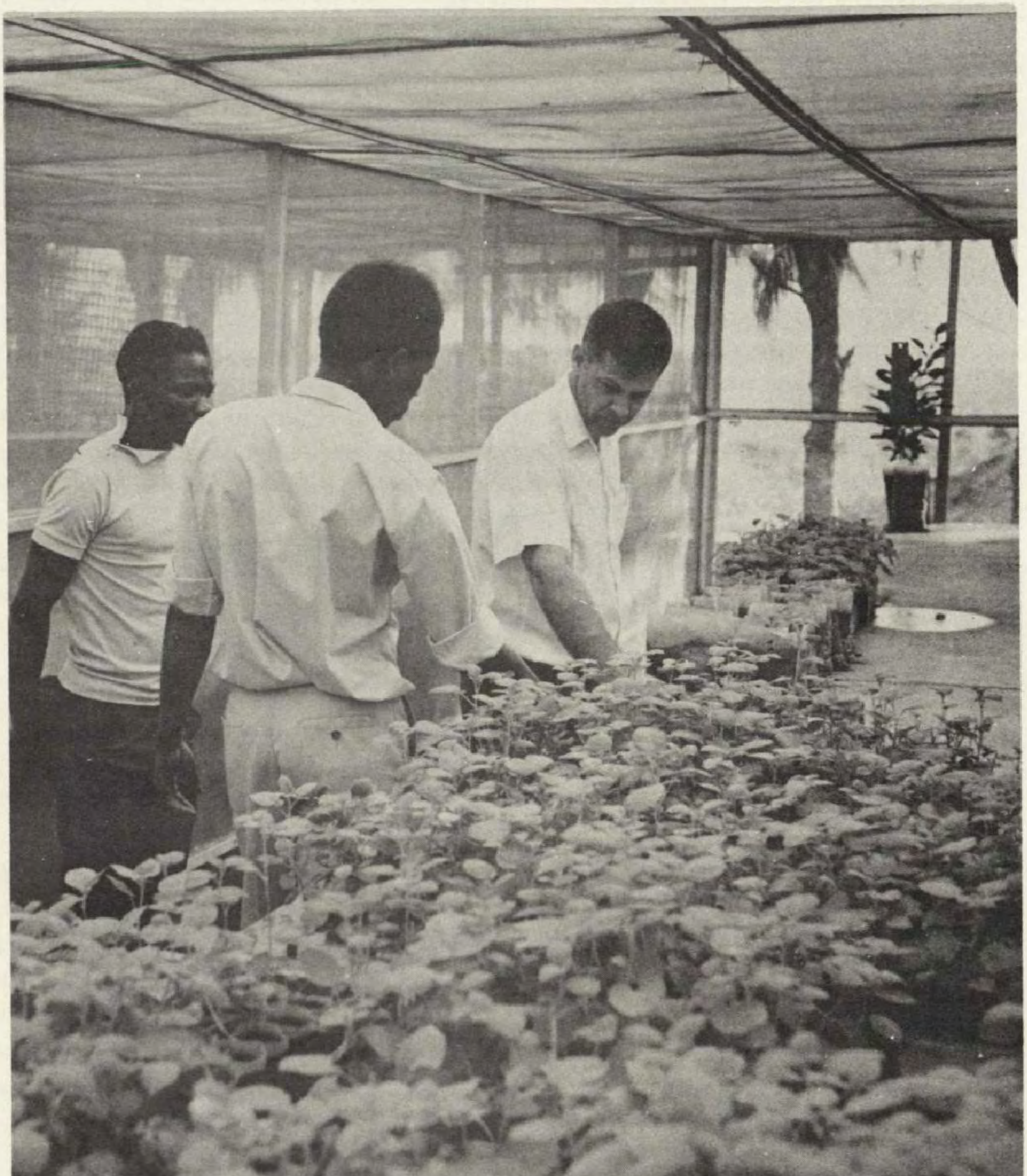

FIGURE 1. Screened potato propagating house used for the production of seedlings and the rapid vegetative multiplication of potato clones in Kampala, Uganda.

TABLE 1. Races of Phytophthora infestans identified from isolates collected in Uganda and Kenya.

Host	Location	Races	Frequency
Potatoes	Kabanyolo	1,3,4	2
		2,3	8
		2,4	5
		3,4	13
Potatoes	Kigezi	1	7
		4	11
		1,4	6
		2,4	3
		2,3,4	5
		1,2,3,4	5
		1,2,3,4,5	3
Potatoes	Toro	4	3
		2,3	1
Potatoes	Embu	1	2
		4	5
		2,3	6
		1,3,4	4
		1,2,3,4,7	9
Potatoes	Limuru	1,2,3,4	4
Potatoes	Nyandarua	1	3
		4	5
		3,4	3
		1,2,3,4	6
Potatoes	Naivasha	4	3
Potatoes	Molo	1,4	6
		1,2,4	4
		2,3,4	6
Tomatoes	Kabanyolo	0	6
		4	5
Tomatoes	Mukono	0	3
		4	2
Tomatoes	Nairobi	3,7	4
	Total number of isolates identified		158

TABLE 2. Percentage of Isolates according to race collected from potatoes in Uganda and Kenya.

Race	Frequency	Per cent of Isolates Identified
4,	27	19.5
3,4	16	11.6
2,3	15	10.9
1,2,3,4	15	10.9
1	12	8.7
1,4	12	8.7
2,3,4	11	8.0
1,2,3,4,7	9	6.5
2,4	8	5.8
1,3,4	6	4.3
1,2,4	4	2.9
1,2,3,4,5	3	2.2
	138	100.0

TABLE 3. Mean Blight indices of some potato varieties grown at Kabale, Kigezi, and Kabanyolo Farm, Makerere University, Kampala.

Variety	Index Kabanyolo (1968)	Kabale (1968)	Kabale (1969)	Kabale (1970)
1. Ambassadeur	2.0	2.0	3.0	4.0
2. Alpha	3.0	3.0	5.0	-
3. Arran Victory	3.5	4.5	-	-
4. BD-3	0.0	0.0	3.5	-
5. B-53(Roslin Eburu)	-	2.5	3.5	3.5
6. Furore	3.0	2.0	4.0	-
7. Gineke	3.5	4.0	-	-
8. N°16	3.5	4.5	-	-
9. N°21	2.5	3.5	-	-
10. N°22	3.0	3.0	5.0	-
11. N°23	-	3.0	5.0	-
12. N°25	4.0	2.5	5.0	-
13. N°26	-	2.5	3.5	-
14. N°27	3.0	3.0	4.0	-
15. N°31	3.0	2.5	4.0	-
16. N°33	4.5	5.0	-	-
17. N°34	2.0	2.5	3.5	-
18. N°35	4.5	5.0	-	-
19. Projfit	2.5	2.0	5.0	-
20. RW-2 (Kenya Akiba)	0.0	0.0	0.0	1.0
21. Pimpernel	2.0	2.0	4.0	-
22. Susanna	0.0	0.0	5.0	-
23. Voran	2.0	2.5	3.5	-

Key:

0 = no blight present

1 = blight lesions difficult to find (5-10 lesions per plant)

2 = blight lesions very evident, but no more than 25% of plant affected.

3 = plants moderately diseased, up to 50% of foliage affected

4 = plants severely defoliated, but not dead

5 = plants dead

Akiba has been rated as 0 to 1 for late blight until the first growing season of 1972 when Kenya Akiba received a blight index of 3.

The progress of late blight in progenies of 19 crosses as expressed by percentage of plants attacked by disease in field trials at Kigezi is presented in Table 4. Some plants from all crosses showed susceptibility to late blight within 18 days after sprouting, and more than half of the plants of most lines had been eliminated by disease by 46 days after sprouting. The percentage of plants surviving from a single cross after one growing season varied from 0.5% for the most susceptible line to 22.9% for the line most resistant to late blight.

A comparison of the performance of some Uganda selections in late blight trials at Kigezi, Uganda, and the Toluca Valley, Mexico, is shown in Table 5. In all cases, the late blight attack was more severe in the Toluca Valley test than in Kigezi. Only a few of the lines selected for blight resistance in Kigezi demonstrated a useful level of field resistance in the Toluca Valley test; and have been chosen for seed multiplication and varietal release in Uganda.

Discussion

The present study on the races of P. infestans indicates that a number of new races have evolved since the races of the pathogene were first identified by Nattrass (9) in Kenya, in 1950. The increase in the number and complexity of races of the pathogene on potato over a twenty-year period is probably due in part to introduction of new R-gene resistant hybrids into East Africa. Undoubtedly, the evolution of new races of P. infestans is a continuing process as new genotypes of the host are introduced. The high degree of mutability of the pathogene, therefore, makes the use of the single dominant gene type of resistance of questionable value in the development of late blight resistant varieties.

The fact that the greatest number of races of P. infestans from one region were identified from isolates collected from Kigezi, helps to explain why a number of potato varieties (Table 3) which are grown elsewhere in East Africa, become susceptible to late blight in Kigezi. For this reason and because of the almost constant cool and moist conditions prevailing during the growing season, Kigezi is probably one of the most severe "screens" for late blight in East Africa. Nevertheless, most of the lines which were selected for disease resistance in Kigezi, were severely attacked by late blight in the Toluca Valley (Table 5) indicating that the Toluca Valley test is a more severe

TABLE 4. Late blight progress in progenies of 19 crosses as expressed by percentage of plants attacked by disease in field trials at Kigezi, Uganda.

Breeding line	N° of plants	Days After Sprouting 18	32	46	60	74	88	102	% Survivals	N° of plants surviving
B4557-2xB5011-17	211	19.43	24.17	50.71	75.82	82.93	90.99	97.15	2.85	6
39 - 1 x 245 - 2	214	23.36	30.37	60.74	63.55	70.63	76.63	80.84	19.16	41
39 - 1 x Merimac	183	7.65	25.68	36.06	63.39	65.57	85.24	93.44	6.56	12
B5755-8 x B3956-1	340	8.82	28.23	48.83	61.76	71.47	95.58	97.64	2.36	8
B5408-2 x B5281-1	49	10.20	16.32	30.61	42.85	63.26	73.46	79.64	20.36	10
B5700-1 x 245-2	109	6.42	17.43	35.77	60.55	76.14	81.65	85.32	14.68	16
B5687-12 x B5000-18	87	16.09	21.83	44.82	55.05	68.96	81.60	87.36	12.64	11
B5052-7 x B5090-11	215	3.72	20.46	27.44	29.76	43.72	74.88	84.65	15.35	33
B5701-5 x B5755-8	83	2.40	8.43	30.12	33.73	44.57	65.06	77.10	22.90	19
B5052-7 x Seranac	79	10.26	15.20	26.60	36.71	44.30	67.08	78.48	21.52	17
245-2 x 168-3	146	6.85	35.62	63.01	80.82	81.50	89.04	90.41	9.59	14
B5708-2 x B5066-3	153	13.07	45.10	54.90	77.12	79.08	84.31	86.27	13.73	21
B5701-2 x B5011-17	186	42.47	67.20	72.58	89.24	93.01	95.69	99.46	0.54	1
Wouseon x B607-56	174	25.43	57.47	63.21	86.78	91.95	97.70	98.85	1.15	2
245-2 x B3139-24	207	43.47	63.80	72.46	88.40	89.37	93.71	89.55	1.45	3
Teton x 245-2	208	11.05	57.17	69.71	82.69	84.13	84.61	91.34	8.66	18
B5701-4 x Merimac	445	23.59	46.51	68.98	90.78	93.38	94.38	95.73	4.27	19
B5669-4 x 245-2	133	7.51	24.06	29.31	44.36	63.90	81.20	95.48	4.52	6
B4784-1 x B5000-18	238	23.52	42.43	64.44	68.90	74.78	87.39	92.01	7.99	19
Total	3460								7.98%	276

TABLE 5. The performance of Uganda potato selection in late blight field trials at Kigezi, Uganda, and Toluca Valley, Mexico.

Cross	Selection Number	Mean Blight Index	
		Kigezi	Toluca
B5701-4 x Merimac	1	1	2+
B5701-4 x Merimac	2	0	3+
B5052-7 x Seranac	1	1+	4
B4784-1 x B5000-18	1	0	5
B4784-1 x B5000-18	2	1	4
B5755-8 x B3956-1	1	0	2+
B5755-8 x B3956-1	2	1	2+
B5755-8 x B3956-1	4	1	3
B5669-4 x 245-5	1	1	2+
B5669-4 x 245-5	2	1	3+
B5669-4 x 245-5	3	2	4+
B5701-5 x B5755-8	1	1	4+
B5701-5 x B5755-8	2	1	4+

screen for resistance to the disease. For this reason and because of the large number of physiological races of P. infestans which are present in Mexico, the Toluca Valley test is very valuable in identifying field resistance which is potentially useful in Uganda. Clones which received a rating of 2+ for late blight in Mexico, have been rated from 1 to 1+ in Kigezi for five consecutive growing seasons.

The results of the present study indicate that resistance stability can only be achieved through the use of new potato varieties selected on the basis of an adequate level of multiplegenic resistance. Nevertheless, the expression of field resistance is not an absolute quantity and may vary with geographical location and environmental conditions. For example, the performance of the variety Roslin Eburu, which possesses genes $R_1R_2R_3R_4$ for resistance to late blight, must be due to field resistance, since race 1,2,3,4 has been identified both in Kenya and Uganda. However, where Roslin Eburu exhibits field resistance rated at 2+ in Kenya (2) the variety has consistantly been rated as 3+ in Uganda.

Black (2) described field resistance as a complex character representing the combined effect of genetic factors controlling (i) resistance of the plant to infection, (ii) rate of spread through the tissues after infection has taken place, (iii) time required to initiate sporulation, and (iv) number of spores eventually produced. In the present study, the different levels of field resistance exhibited at different geographical locations by the same host genotypes indicate that the environment may modify the effect of genetic factors controlling field resistance.

Summary and Conclusions

Late blight caused by *Phytophthora infestans* is the most serious factor limiting potato production in Uganda. A survey of the races of *P. infestans* was initiated to determine the degree of race specialization of the pathogene that has occurred in the past 20 years. In addition to confirming the existence of races of *P. infestans* already reported in Kenya, nine additional races were identified in Kenya and Uganda. The most common races were 4, 2,3, 3,4 and 1,2,3,4. The greatest number of races from any one region were identified from isolates collected from Kigezi, western Uganda. Field trials were conducted in Kigezi with a collection of varieties and clones existing in East Africa, and none were found to have sufficient resistance to late blight to be grown without the aid of protective sprays. New germ plasm was introduced as true seed and over 50,000 seedlings were screened for resistance to late blight. The relatively few surviving clones were tested for field resistance to late blight in the Toluca Valley, Mexico. Only a few lines selected for blight resistance in Kigezi demonstrated a useful level of field resistance in the Toluca Valley test and are now being multiplied for varietal release in Uganda.

The results of the present study indicate that resistance stability can only be achieved through the use of new potato varieties selected on the basis of an adequate level of multiplegenic resistance to late blight. Only varieties which possess such field resistance and which are adapted to the environmental conditions of the major potato growing areas of the country are likely to increase potato production in Uganda to a significant extent.

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THE LATE BLIGHT TESTING PROGRAM IN MEXICO

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The first Mexican field trials for resistance to late blight (*Phytophthora infestans*) were conducted at the Chapingo Experiment Station in the Valley of Mexico during the summer of 1948. These early trials not only demonstrated that this disease was a limiting factor in summer (rainy season) potato production on the Mesa Central, but perhaps even more important, that there was something special about the population of races of *P. infestans* prevalent there. Differential clones used for identification of pathogenic races were all severely attacked.

By 1951 more than 30 introduced commercial varieties, described elsewhere as having levels of resistance up to "immunity", were tested in the field in Mexico and found to be completely susceptible there. On the other hand, a few varieties not particularly noted for resistance to *P. infestans*, were found to have an interesting, though low-level, "field resistance" to this pathogen.

During these first years it was also observed that certain clones of Mexican wild species (e.g. *Solanum demissum*, *S. bulbocastanum*) were highly resistant, even though no clone of any tuber-bearing Solanum species was ever found to be completely free of attack. In 1953, a program was initiated to incorporate this "field-resistance" of the wild species into an agronomically acceptable potato variety that could produce a satisfactory yield without fungicidal protection during the rainy season. Using wild Mexican species and a few resistant introduced clones for a germplasm base, a breeding program was launched. Segregating seedling populations were annually exposed to the selection pressure of the late blight epiphytotic in the field. Within ten years more than a dozen blight-tolerant varieties had been released, a collection of more than 500 resistant clones had accumulated, and much of this resistant germplasm had been distributed to potato breeding programs throughout the world.

With the distribution of this resistant material, interest in the Mexican late blight field test rose rapidly. By 1955 segregating seedling populations were being received from several potato breeders in Europe and North America, and this field trial was truly international.

Exposure in the field at Toluca provided a screen for field resistance that was perhaps unequalled elsewhere in the world. Monogenic hypersensitivity provided little protection here. The subsequent discovery of the role of the sexual oospore in the annual epiphytotics explained why there was "something special" about the population of races of P. infestans in Mexico. And confirming early observations, during 20 years of field testing of resistant materials from all over the world as well as Mexico, no seedling or clone of any tuber-bearing Solanum has ever been found to be immune to blight in the field at Toluca.

As the best of the Mexican blight-resistant clones were used in other breeding programs, it became of critical importance to test the segregating generations of seedlings, not only with locally prevalent races, but to return the more promising selections to Mexico and identify there which clones had inherited the highest levels of resistance from their Mexican blight-resistant ancestor. This is the primary objective of the International Late Blight Field Trials conducted each year in the Toluca Valley in Mexico.

During the past 20 years approximately 132,000 seedlings and 31,954 selections have been tested for blight resistance in the field at Toluca for potato breeding programs in 29 countries (Argentina, Australia, Bolivia, Brasil, Canada, Colombia, Costa Rica, Chile, Denmark, East Germany, Ecuador, England, France, Guatemala, India, Ireland, Japan, Kenya, Netherlands, New Zealand, Pakistan, Peru, Poland, Scotland, Soviet Union, Sweden, Uganda, United States, West Germany). The greatest impact of the Mexican field test has been the inclusion of highly resistant germplasm in the major potato breeding programs of the world. This field test has provided the plant breeder, wherever he may be working, with a reliable and severe screen for field resistance to Phytophthora infestans.

Mexico's contribution to our knowledge of late blight and its pathogen has not been limited to the international screening program. Pioneering research has been conducted there on: (1) The sexual oospore, its genetics and role in the life history of the fungus; (2) the genetics of field resistance; (3) stability of field resistance; (4) resistance at dihaploid (24 chromosome) levels; and (5) sources of resistance in addition to S. demissum.

As we consider the potential of the potato in the developing world, I wish to underline the importance of a stable late blight resistance in any potato variety destined for extensive cultivation in these countries where the small farmer rarely has the resources necessary for frequent and effective fungicide applications. As we arm our program to push the potato into new regions where its unrealized potential is so great, I stress that the Mexican late blight field trial has a vital and well-established role to play.

SIXTH SESSION

BREEDING FOR GOLDEN
NEMATODE (Heterodera rostochiensis)
RESISTANCE

Chairman, Hans Ross
Professor, Max-Planck-Institut

BREEDING FOR GOLDEN NEMATODE RESISTANCE IN THE UNITED STATES

Ronald E. Anderson and Bill Brodie
Cornell University, U.S.A.

Nematologists first became aware of the presence of the golden nematode in the United States after a Long Island, New York, farmer noticed that potato plants were growing poorly in one of his fields. In 1941, the cause of his trouble was determined to be the golden nematode (Mai, 1964). Surveys show that approximately 18,000 acreas have been infested in Long Island. In 1967 a much smaller area of infestation was found in south-central New York. The newer area may have been initiated from viable nematodes on the farm equipment and seed stocks of a farmer who moved from Long Island to Steuben County in the mid 1940's. To date these are the only two known areas of infestation in the United States.

Quarantine regulations have been promulgated to protect other potato growing areas in the United States from the golden nematode. Host crops may not be grown on land known to be infested. Extensive yearly surveys are conducted to determine local spread. Movement of soil, machinery, and plant materials is regulated, and seed potato production is prohibited in the infested areas.

The recent availability of cultivated varieties with high levels of resistance to the golden nematode has added a powerful tool to the overall control program. Highly effective soil fumigation, use of resistant varieties, and application of systematic nematicides have been shown to reduce the population of nematodes to very low levels. As of December 1971, treatment and urban development have reduced the infested area in Long Island to 900 acres and the Steuben County area to 55 acres.

Testing for resistance to the golden nematode was begun on Long Island in 1947 (Mai and Peterson 1952). In these tests all varieties and seedlings of S. tuberosum were highly susceptible, as were fifty-three of fifty-five wild tuber-forming species. The two exceptions were S. vernei (Ballsii) and

S. sucrense, which showed excellent resistance in three successive years of testing. The Ballsii material was lost when it failed to hybridize with commercial varieties, and the original S. sucrense accessions were lost because of virus infection. The real value of these early trials was the evolution in 1949 of the screening procedure which remains our basic method of determining resistance; i.e., by counts of numbers of immature females on the roots exposed when the intact soil ball of a young potato plant is removed from the clay pot.

The identification of resistant individuals by an efficient, effective, and repeatable screening procedure is critical in a program of breeding for resistance. The evaluation method herein described is common to both the Long Island Nematode Research Laboratory and the Cornell-USDA facility at Ithaca (Harrison 1968; Mai 1970).

Soil heavily infested with Heterodera rostochiensis (40,000 larvae/ 150 ml of soil) is collected from the field just after potato harvest (October). This soil is thoroughly mixed with sand in a proportion of 3 parts infested soil to 1 part sterile sand. The material to be evaluated is planted in a 3-inch clay pot containing the infested soil mixture. The pots are either set directly on a greenhouse bench or sunk in sand in a greenhouse bench. Temperature in the greenhouse is regulated to maintain a soil temperature of 20-24°C. If necessary, heating cables are used to maintain the soil temperature. Also, in cases where examination of the root system without disturbing the plant is desired, transparent plastic pots are used instead of clay pots.

The plants are evaluated for resisrance 8-10 weeks after planting. The immature white cysts on the outside of the root ball are counted. Those plants with 5 cysts or less are considered resistant and those with more than 5 cysts are considered susceptible. In some cases, depending on the objective of the program, where no cysts are found on the outside of the root ball the roots are washed free of soil and the entire root system is examined for cysts.

To preclude chances of escape, material that is rated zero (no cysts) in greenhouse evaluation is further evaluated in field plots heavily infested with H. rostochiensis. This evaluation is done in the growing season when environmental conditions are most favorable for H. rostochiensis development. Individual tubers produce on plants that rated zero in greenhouse tests are planted in a uniformily infested plot. Individual plants are dug 10-12 weeks after planting and the cysts are washed from the roots and counted. The rating system used in greenhouse evaluations is also used in field evaluations.

The next cycle of breeding for nematode resistance was based on the resistant clone C.P.C. 1673 of *S. tuberosum* subsp. *andigena*, identified by Ellenby and sent to us by Dr. Toxopeus as F_1 seed. The variety Peconic (Peterson and Plaisted 1966) is typical of other golden nematode resistant material in the Cornell breeding program. The pedigree for Peconic is as follows:

Peconic (NUR-20) (NY-1)
- LNA-106
  - Russet Rural
  - 1392-7
    - Record
    - C.P.C. 1673-1 *S. tuberosum* subsp. *andigena*
- Katahdin

The family from which NY-1 was selected was grown as seedlings in 1957. It was grown as a 10-hill selection in 1960, having survived the usual nursery selection criteria as well as annual tuber indexing for golden nematode resistance at the Long Island Nematode Laboratory. The variety was released in 1966 following extensive testing for yield, specific gravity, chipping, etc., and preliminary increase and evaluation of seed stock. Additionally, Peconic has been tested in Newfoundland, Canada, where it was found to be resistant to their race of the golden nematode.

Peconic and many other Cornell tetraploid breeding lines derive their resistance to the golden nematode from the subspecies *andigena*. Thus far only pathotype A has been found on the infested New York soils, and the *andigena*-type resistance has remained fully effective against this form of the pathogen. The use of resistant varieties in New York, together with systematic nematicides, and following effective chemical soil fumigation, should routinely result in small residual populations of nematodes and thus decrease the probability of development of genetic variants capable of infecting these varieties. However, the recent serious and widespread outbreak of *Helminthosporium* leaf blight of maize in the United States points up the hazard of monoculture, due in this instance to almost exclusive use of one genetic source of cytoplasmic male sterility.

Andigena-type resistant potatoes are known to be susceptible to other pathotypes of the nematode in Western Europe, Great Britain, and Peru. It matters little whether these pathotypes are mutant forms arising *de novo*, admixtures of heterogeneous types responding to environmental stresses, or differing introductions from a center of diversity. Natural competition for survival may effect either of the first two alternatives in New York. Man in his travels and incomplete quarantine favor the occurrence of the third.

The need to have alternate sources of resistance in the breeding program has stimulated genetic research with several of the diploid species of Solanum. However, the genetic analysis was primarily based on reaction to pathotype A, though comparable research in other laboratories on the same species would infer a more broadly based resistance in some cases. Plaisted et al (1962) proposed a genetic model of inherited resistance in S. vernei involving dominant genes at two loci, with a dominant modifier affecting levels of resistance at a third locus. Momeni (1968) studied the inheritance of resistance to golden nematode using the diploid species S. spegazzinii, S. neohawksii, and S. sanctae-rosae. He concluded that certain clones of both S. spegazzinii and S. neohawksii were resistant due to single dominant genes. The most resistant progeny was derived from S. sanctae-rosae, with nearly 73 percent of the individuals completely free of cysts. However, the data would not distinguish between resistance conferred by one or two major genes.

The most definitive genetic research on resistance to other races of the golden nematode has been that of Dr. Maria Mayer de Scurrah (1972). During 1970 and 1971 she tested for resistance to three indigenous populations of nematodes at two locations in Peru. The Solanum materials resistant in New York included tetraploid tuberosums with resistance derived from both andigena and vernei, as well as a selection of diploid vernei clones. Half of the diploid vernei clones showed resistance to one or more of the Peruvian nematode populations, but the tuberosum varieties were equally susceptible, indicating that the vernei resistance had been lost in the backcrossing procedure.

The interaction of the New York breeding materials of Solanum species with the agressive and diverse indigenous nematodes of Peru has prompted Cornell to initiate a program designed to identify diverse sources of resistance, to analyze them genetically, and to incorporate them into adapted tetraploid breeding materials. Testing in Peru will be an integral part of this program, both to assist in the identification and genetic analysis of resistance as well as to insure the maintenance of level of resistance in advanced generations.

It is proposed that in the early cycles of screening for resistance, emphasis will be placed on diploid Solanums, using haploid S. tuberosum material for test-crosses and as a genetic bridge to the tetraploid material for incorporation into breeding lines.

Sixty diploid clonal lines were used as parents in production of hybrids in early 1972. About one-fourth of the diploids had shown resistance in

both New York and Peru; the remainder are resistant in New York and untested elsewhere. Eighty tetraploids resistant to New York pathotype A and tracing to parents showing resistance in Europe were crossed to adapted varieties.

We hope to be able to build a gene pool of resistance factors by use of inter-specific and multi-species crosses, using as parents individuals with total resistance to pathotype A. Seven thousand seedlings are now in the field, tracing to such parental clones from the diploid species vernei, neohawksii, spegazzinii, and sanctae-rosae. Other diploid species have been received from the Potato Introduction Station at Sturgeon Bay, Wisconsin, and they will be introduced into the program when and if resistant clones are identified.

Cooperative testing with the International Potato Center will screen more rigorously for those individuals which are resistant to the aggressive pathotypes of the Andes. As potential breeding material is produced at either the diploid or tetraploid level, it will be grown for agronomic evaluation in both Peru and New York. Thus promising germ plasm in one location will not be discarded because of poor adaptation to the alternate set of growing conditions.

Another facet of the breeding program which will utilize the extensive Cornell collection of S. tuberosum subsp. andigena will be a search for general tolerance in this material comparable to the field resistance to late blight found in S. demissum. The determination of selection criteria for field tolerance will be the responsibility of the nematologists on the research team. The best clones will be intercrossed to produce material for recurrent cycles of selection. If this method results in quantitative differences under New York nematode infestations, the selected variants will be tested in Peru for the critical evaluation of general tolerance.

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BREEDING FOR RESISTANCE TO THE POTATO CYST-NEMATODE IN THE NETHERLANDS

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Already before the last World War a search for resistance to the potato cyst-nematode (Heterodera rostochiensis Wollenweber) was made within the cultivated potato varieties of Western Europe and the U.S.A., but a usable degree of resistance was not found.

The English nematologist Ellenby was the first who started looking for resistance in collections of wild and primitive potatoes. During quite a number of years he screened the Commonwealth Potato Collection (CPC) and though he used primitive methods for the detection of resistance, he demontrated the existence of this highly desired property in the diploid species Solanum ballsii (= S. vernei) and in three lines of the tetraploid species S. andigenum (Ellenby, 1945). Curiously, his important findings were not followed up by a breeding programme in the United Kingdom.

In 1951 Dr. Dodds, then director of the CPC, sent about 40 seeds of each of the three andigenum - lines to Dr. Toxopeus then leader of the Wageningen Potato Collection (WAC). Toxopeus gave the seeds to the first author who confirmed the existence of the resistance, launched a hypothesis on the mode of inheritance of the resistance, and started an ambitious breeding programme in 1952 (Ellenby, 1952, Toxopeus & Huijsman, 1952).

In accordance with the principles of the Foundation for Agricultural Plant Breeding this breeding programme aimed at the production of seeds from crosses between resistant and susceptible clones in which the selection being the task of the Dutch private breeders in which at that time more than a hundred participated. This system proved its effectiveness more than ever and in a very short time resistant varieties could be released.

The andigenum CPC 1673 resistance

Resistant CPC 1673 material exudes a hatching agent in the same amount as susceptible plants, and the number of larvae that invade the roots are of the same order of magnitude in both classes of plants. However, in the roots of the resistant plants most of the females are killed before they reach maturity and can form eggs. This leads to a reduction of the nematode population in the soil of about 80% and in pot-experiments of even more than 90%. This percentage of population-decrease can be used as a measure for the degree of resistance.

The inheritance of this type of resistance in S. andigenum CPC 1673 proved to be very simple: monogenic and dominant (Huijsman, 1955). S. andigenum and S. tuberosum - both tetraploids - cross very easily.

The cross between a resistant and a susceptible plant results in a 1:1 (resistant : susceptible) segregation if the resistant parent has the simplex constitution and in a 5 : 1 segregation for duplex resistant parents.

When a number of seedlings from a cross resistant(simplex) x susceptible is taken at random, each seedling is measured for its degree of resistance and the observations are condensed to a frequency-diagram, results such as are shown in Fig. 1 are obtained. Clearly the seedlings fall into two classes: the distribution-curve of the resistant class shows a small standard deviation and the mean degree of resistance is very high. There is practically no overlapping between the two classes. Such distributions can be explained by assuming no, or at all events very little, influence of a polygenic system on the degree of resistance induced by the major gene for resistance. A consequence for practical work is then that breeders can continue to backcross without fear of a decrease in the degree of resistance.

The other two andigenum - sources of resistance found by Ellenby: CPC 1685 and CPC 1692, were eliminated from breeding work because their degree of resistance was too low.

Results of breeding work with CPC 1673

At the moment the Dutch List of Varieties contains 16 varieties with nematode-resistance: 9 of them are starch varieties, 6 cooking potatoes and one is a first - early variety. The starch varieties are especially very high-yielding and as a consequence their introduction did not encounter any difficulties. In the Dutch starch district more than 80% of the potato-acreage is

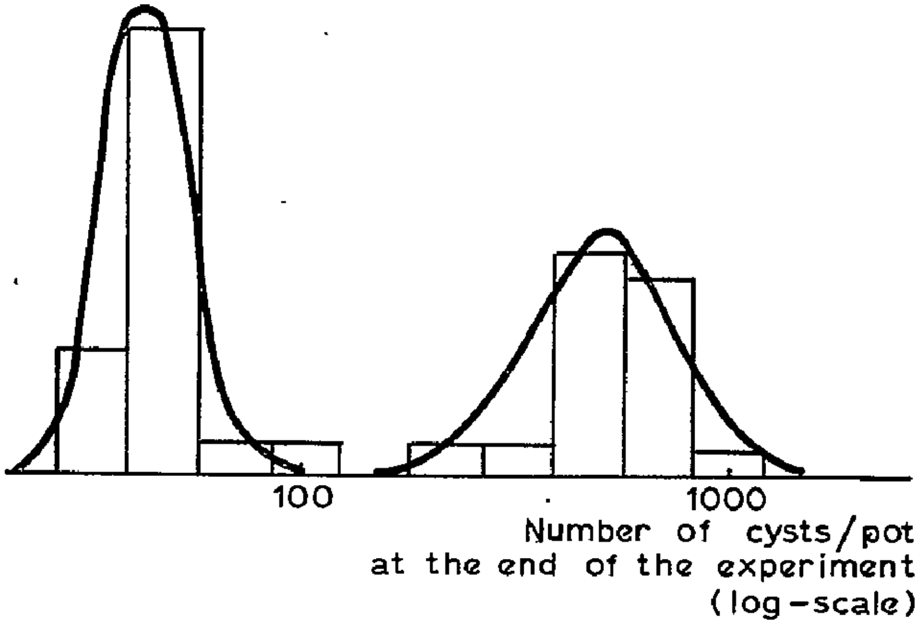

FIGURE 1. Frequency-distribution of the degree of resistance in an aselect population of seedlings of the cross Desirée (susc.) x Provita (res. to path. A). Initial infection: 30 cysts/pot. Pathotype: A. The degree of resistance is measured as the number of cysts per pot at the end of the experiment.

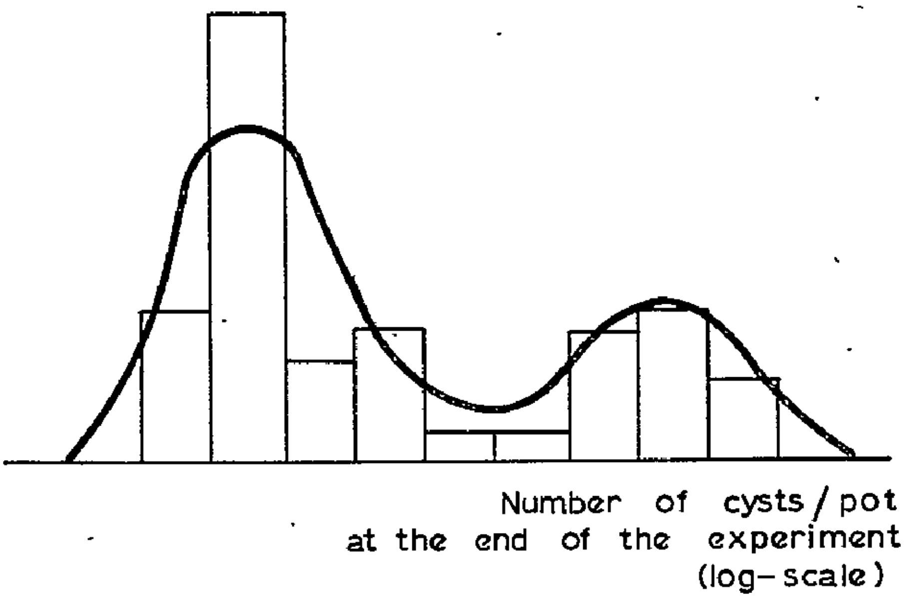

FIGURE 2. Frequency-distribution of the degree of resistance in an aselect population of seedlings of the cross Arka (susc.) x (VT^n) ^{2}62-33-3 (res.; path. A). Initial infection: 30 cysts/pot. Pathotype: A.

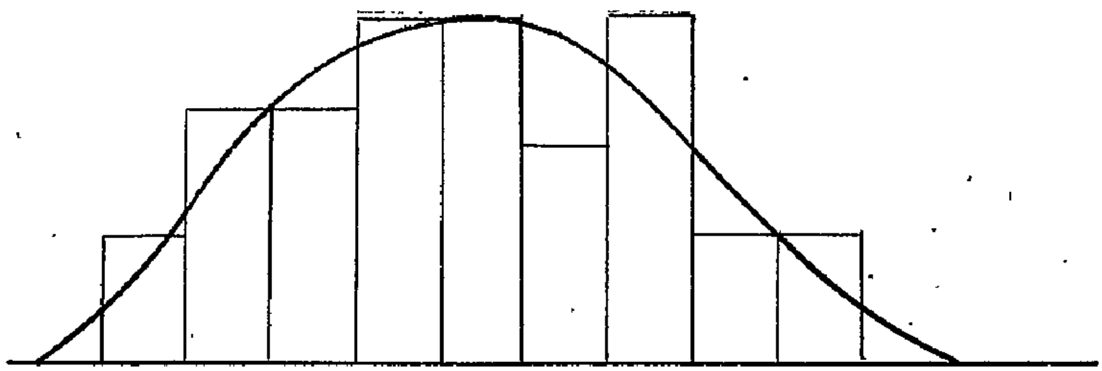

FIGURE 3. Frequency-distribution of the degree of resistance in an aselect population of seedlings of the cross VT^{3} 6[illegible]2-31 (res.) x KW. 65-461 (susc.). Initial infection: 30 cysts/pot. Pathotype: A.

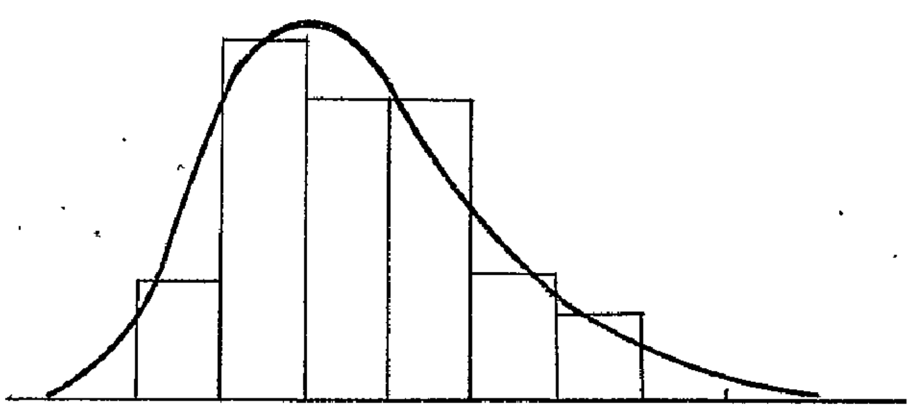

FIGURE 4. Frequency-distribution of the degree of resistance in an aselect population of seedlings of the cross Sissy (susc.) x F. 4 (res.). Initial infection: 30 cysts/pot. Pathotype: D.

covered with resistant varieties. For the Netherlands as a whole about 30% of the potato-acreage is under these varieties.

The greater part of these varieties are second-backcross-seedlings: ATTT (A = andigenum; T = tuberosum).

An interesting point is that the introduction of S. andigenum in potato-breeding has caused an increase in yield potential. As this phenomenon is also met in crosses with other primitive and wild forms, it is certainly worth a careful study.

Resistance of S. vernei

In order to obtain resistance to certain physiological races of Heterodera rostochiensis, another species is intensively used in Dutch breeding work: S. vernei, a diploid species (Series XVII). In the beginning of the breeding programme many sources of resistant vernei material were used, but in the course of time practically all this material was discarded with the exception of the progeny derived from CPC 3000(?) of which F.1-seeds were given to us by Dr. Howard (Cambridge, UK). The resistance in CPC 3000 to race A (see later) is also governed by major genes as is obvious from Fig. 2. By comparing Fig. 1 and 2 it is seen that the mean degree of resistance of the vernei-gene is less than that induced by the 1673-gene but also the standard deviation of the resistant population is larger. There is more overlapping of the two classes, resistant and susceptible, compared with the andigenum-material. One could argue that there is a large influence of a polygenic system on the degree of resistance with as a consequence a much larger variation in the degree of resistance in the class of resistant seedlings of a cross and as a consequence a continuous transition of resistance to susceptibility.

This means that breeding for resistance with S. vernei is a very complicated task. The selection of seedlings with the highest possible degree of resistance is difficult and when mistakes are made in this respect one may expect that backcross-generations which have been made with a low-resistant parent will possess a disappointing distribution of the degree of resistance (Fig. 3).

The inheritance of resistance of the vernei - material derived from CPC 3000 to D-races (see Table 1) is also not simple. When frequency-diagrams are made with a select population derived from the cross resistant x susceptible according to the methods already described, unimodal distribution curves are obtained (Fig. 4). Obviously polygenes have a major influence in the mode of inheritance of this resistance.

Results of breeding work with S. vernei as a base.

At the moment our List of Varieties (1972) includes one variety derived from S. vernei: Amalfy and two varieties which are available for farmers for practical use on a small scale: Mara and Proton. The starch-content of these two varieties is exceptionally high. There are numerous very promising varieties competing for admittance to the List of Varieties, so that it may be expected that in the next few years there will be an abundance of choice of varieties with resistance based on that found in S. vernei. Many of them have an exceptionally high yielding capacity.

Physiological races of the potato cyst-nematode.

The reason why S. vernei is used in breeding for resistance to the potato cyst- nematode, is that the resistance in this species protects against several physiological races of the parasite which can survive and multiply in the roots of the resistant CPC 1673 material. A survey of the Dutch Plant Protection Service showed that about 80% of the infested area in the Netherlands has the "normal" or A-race which can be controlled with the andigenum-based varieties; the remainder has resistance-breaking races.

Immediately after this discovery a breeding programme for resistance to these dangerous races was started. The wild diploid species S. kurtzianum was used as a source of resistance but after some years it was found that the protection given by S. kurtzianum was not enough and S. vernei became the new base for our breeding work.

For the classification of the races or "pathotypes" a number of test-plants is used. The composition of this test-series reflects the breeding-history in the Netherlands. In other European countries other test-plants are used. International comparison between the existing pathotypes is therefore difficult. The scheme used in the Netherlands today is given in Table 1.

Some of the clones in this assortment have more than one gene for resistance and thus are less suitable for the purpose of detecting the highest possible number of pathotypes with the least number of test-plants. However, there is not a better series available at the moment in our country.

Ross and Huijsman have demonstrated that the number of pathotypes increase as more different genes for resistance are included in the test -series. Theoretically, if n different genes for resistance are used, 2^n different patho-

TABLE 1. Test-assortment and nomenclature of pathotypes of H. rostochiensis used in Netherlands.

	A	B	C	D
S. tuberosum - variety	susc	susc	susc	susc
S. andigenum CPC 1673-var.	res	susc	susc	susc
S. kurtzianum-hybrid	res	res	susc	susc
S. vernei-hybrid OD.* 22731	res	res	res	susc
S. vernei-hbr. $(VT^n)^2$ 62-33-3	res	res	res	res

* OD = DDR (Eastern Germany)

types can be distinguished from each other (Ross & Huijsman, 1969).

The words "pathotype" and "physiological race" have been used too easily as has been shown recently. According to English nematologists there are two species of the potato cyst-nematode (Trudgill & Parrott, 1971). One species, the normal Heterodera rostochiensis with the colour change in maturing females of white via orange to brown and among other characteristics a relatively short mouth-spear, and another species with a colour change white straight to brown and a relatively long mouth-spear.

It is obvious that in future in classifying pathotypes, first the species must be determined, and then within this species the pathotype.

Of course much research must be done before the new situation is sufficiently clear. However, for the Netherlands the following situation is likely to exist. To the true species H. rostochiensis belong the pathotypes A and B. In the varieties derived from CPC 1673 (S. andigenum) and in the variety Amalfy derived from S. vernei CPC 3000, resistance to these pathotypes exists. Given two genes for resistance there must be 4 pathotypes present. Only two of them have been found so far. To the new species, with the long mouth spear, belongs pathotype D. There is not enough material at our disposal to draw any conclusions about pathotype C.

Resistance to pathotype D is present in part of the material bred from S. vernei CPC 3000. However, if plants of a resistant clone are inoculated with a large collection of D-races, it is observed that the degree of resistance varies largely: the range being from a decrease of the initial popula-

tion of about 80% to an increase of the population with a factor 2-3.

In the case of the D-resistance difficulties are encountered in the Netherlands. D-resistance is present in the material now already used by the private breeders. The question what kind of D-cysts must be used in the official testing for resistance however is not yet solved.

Sources of resistance

We still hope that a better type of resistance - without disturbances by the occurrence of new pathotypes-will be found. The screening of collections of wild and primitive forms is an important task of our institute. It is not possible to maintain the collected material once it has been found susceptible. As 99.9% of the collected plants are susceptible, we are better off with a continuous stream of new material which is tested for resistance and which is discarded when found susceptible, than by maintaining very large numbers of clones, which is an expensive procedure.

Resistance to the potato cyst - nematode has been found in the following species:

a) Cultivated species:

Series XVII Tuberosum	: S. andigenum	(2n = 48)

b) Wild species:

Series XVII Tuberosum	: S. cajamarcense	(2n = 24)
	S. microdontum	(2n = 24)
	S. chiquidenum	(2n = 24)
	S. kurtzianum	(2n = 24)
	S. vernei	(2n = 24)
	S. spegazzinii	(2n = 24)
	S. multidissectum	(2n = 24)
	S. sparsipilum	(2n =24)
	S. marinasense	(2n = 24)
	S. leptophyes	(2n = 24)
	S. canasense	(2n = 24)
	S. oplocense	(2n = 24, 48)
	S. sucrense	(2n = 24)
Series VI Commersoniana	: S. chacoense	(2n = 24)
Series X	: S. acaule	(2n = 48)
Series XIV Cuneolata	: S. infundibiliforme	(2n = 24)
Series XV Megistacroloba	: S. sanctae-rosae	(2n = 24)
	S. megistacrolobum	(2n = 24)

The above list of course does not mean that every sample of the above mentioned species is resistant. It is estimated that in S. andigenum several thousand provenances had to be tested to find less than 5 resistant plants. Nor does the list mean that each resistant species has genes of resistance distinct from those of other species.

The advantage of certain wild species concerning resistance to many pathotypes as compared with resistant varieties or breeding clones may be due to a loss of resistance - genes in these cultivars as a consequence of too much backcrossing and testing against a restricted number of cyst-samples - a task hampered by shortage of money and labour resources.

To decrease this danger of loss of resistance inbreeding generations must be inserted between backcross generations when working with, for example, S. vernei.

Use of resistant varieties in the Netherlands.

The use of resistant varieties in the Netherlands is controlled completely by laws. The control of the potato cyst-nematode is based on

a) crop - rotation
b) resistant varieties,
c) chemical desinfection of the soil.

In principle these three control - measures are used in such a way that they decrease the infestation with nematodes in the long run. Infested fields are subjected to certain specified combinations of these control-measures. If infested soils decrease to a very low level of infection they are admitted to the uninfested area and treated as such.

Resistant potato varieties decrease the eelworm-population in the soil. Nothing has been said about the damage done to the potato plant by the parasite. Resistant varieties in general are intolerant to the potato cyst-nematode: there is an important yield reduction when these varieties are planted on highly infested fields.

In some susceptible potato varieties we have found tolerance to the potato cyst-nematode (Huijsman, Klinkenberg en den Ouden, 1969). An outstanding variety in this case is Multa. The tolerance-characters when grown on infested soils of Multa are:

a) a higher tolerance-limit
b) a higher minimum yield.

We have not succeeded until now in combining resistance and tolerance in one variety.

The use of resistant varieties is hampered by the occurrence of pathotypes. Only when strong restriction-measures are taken, breeding of new varieties can decrease the spread of pathotypes. Tolerant varieties in themselves offer no difficulties as concerns pathotypes; however, the spread of the disease is not checked. In countries where the parasite has spread uniformly and where it is not possible to impose strong restrictions on farmers, breeding for tolerance might be a better aim than breeding for resistance.

A world wide programme could help the breeding of varieties in which resistance and tolerance are combined. If our programme would be helpful, we certainly are willing to participate in such actions.

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VARIABILITY IN HETERODERA ATTACKING THE POTATO IN PERU

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Resistance agains the potato nematode, Heterodera rostochiensis, was first found in S. vernei and S. andigenum in 1952 (2,7). The Andigena clone 1873 from the Commonwealth Potato Collection was found to be most useful for breeding purposes as its resistance is inherited as a single dominant gene, called gene H1. In 1956 and 1957 Dunnet (1) in Scotland and Quevedo, Simon and Toxeopus (9) in Peru found that plants containing this resistance were susceptible when tested with nematode populations from both these countries. These nematodes populations were called "aggressive" and gene H1 was used to differentiate aggressive and non-aggressive populations. Further testing, however, showed that the aggressive types were not uniform and differed in their ability to attack different Solanum hosts.

In Britain and Holland the nematodes were classified as shown in Table 1.

Guile (3) discovered that the females of these nematodes, which can be seen with the naked eye when they swell outside the root during maturation, differed in their chromogenesis during development. Pathotype "A" went through a prolonged golden yellow stage, hence the name "Golden Nematode" given by Chitwood. Pathotypes "B" and "E" remained white or creamy until they were fully mature, when they all turned brown. Further studies showed even more differences between these pathotypes. Second stage larvae of pathotype "A" have shorter stylets, shorter body length and shorter distances between their median bulbs and excretory pores than pathotypes "B" and "E" (10). Also it was found that hardly any cross-fertilizing occurs between pathotypes. Thus, Jones et al at the Rothamsted Station proposed to call the aggressive white types a new species (5).

Studies by Ross and Huijsman (10) showed that a great variation existed within the aggressive and non-aggressive types. Each nematode popu-

TABLE 1. European classifications of Heterodera rostochiensis (Woll.) pathotypes.

	Dutch Classification *			
	S. tuberosum ssp:			
Pathotype	tuberosum	andigena	S. kurtzianum	S. vernei
A	+	-	-	-
AB	+	+	-	-
AC	+	-	+	-
ABC	+	+	+	-
ABD	+	+	-	+
ABCD	+	+	+	+

	British Classification **			
Pathotype	S. tuberosum	Ex-andigena	Ex-multi-dissectum	Combining both genes
A	+	-	-	-
B	+	+	-	-
E	+	+	+	+

* Huijsman, 1962 (5)
** Jones and Parrot, 1965 (7).

lation had a distinctive host range and thus could be differentiated from all others.

Ross and Huijsman assigned a level of aggressivity to each population. For breeding purposes, they found that the more aggressive the nematode population the more suitable for testing in breeding programs it was, since a host resistant to a more aggressive type was likely to be resistant to a less-aggresive type. They also confirmed that the females which turned yellow were less aggressive and could be differentiated by their morphometrics; that is by their smaller stylets and smaller distances from median bulb to excretory pore.

The potato cyst nematode has been found throughout the Andes of Peru and in some areas in densities as high as 350 cysts/ 100 gms. of soil. It

is one of the main causes of small tuber yield and size in the Andean potato growing region. It is thought that this nematode evolved here and was taken to Europe in the nineteenth century.

It is therefore extremely interesting to see what variability of the potato cyst nematode is found in the Andes, compared to the European and North American types, and also to see what sources of resistance can be found for the Peruvian types and to check out if these are useful elsewhere.

The work presented here is preliminary, having begun in 1971.

Three populations of nematodes were selected initially because of their geographical separation. These were field populations near Otuzco, Huancayo and Cuzco. Some work has also been done with populations from Puno and Arequipa which were collected by Ing. Javier Franco and sent to Dr. J. Kort in Wageningen, Holland. The first group of nematodes were also sent to Dr. H. Ross in Köln.

Table 2 shows that the nematodes collected in Huancayo and Otuzco are extremely aggressive, overcoming the resistance in all these lines. The population collected in Cuzco, however, was not able to overcome the resistance in 5 of these lines. Three lines were bred from resistant S. vernei, one from S. spegazzinii and one from S. oplocense.

Table 3 shows tests performed in Europe with nematode populations sent from Peru. S. vernei clones 58.1642/4 and 62.33.3 are used in Holland to differentiate between Pathotype "D" and "E".

Resistance was found when testing with some of the populations. Again, Otuzco is extremely aggressive, as is Puno. According to the Dutch classification, Otuzco, Puno and Cuzco would be some kind of pathotype "E". Huancayo would be a mixture of "D" and "E", Arequipa was not able to overcome the resistance of S. andigenum nor S. vernei clone 62.33.3, and therefore did not fit with the formal classification. Clone 62.33.3 seems to contain a higher level of resistance as it withstood the attack of three populations.

It seems that the nematode populations found in the Andes do not fit easily into the present system of classification and that we may have to develop different tester-plants to find more accurately the extent of the variability and aggressivity of the native nematode populations.

TABLE 2. Susceptibility of resistant tetraploid clones from the U.S. and Europe tested to three populations of Peruvian nematodes.

Source of Resistance	Clone	Source of Inocula Huancayo	Otuzco	Cuzco
Ex-S. andigena	Peconic (U.S.A.)	+	+	+
	Saturna (H)	+	+	+
Ex-S. vernei	NY-24 (U.S.A.)	+	+	+
	GLKS (H)	+	+	±
	65-346/9 (G)	+	+	+
	65-346/19 (G)	+	+	+
	66-1001/2 (G)	+	+	-
	66-1003/42 (G)	+	+	-
	66-1004/11 (G)	+	±	-
	66-1004/19 (G)	+	+	+
	67-64/1 (G)	+	+	±
Ex-S. spegazzinii	64-953/74 (G)	+	+	-
Ex-S. oplocense	67-57-3 (G)	+	+	-

\- Resistant
\+ Susceptible
± More than 5 but less than 20
H Material from Holland
G Material from Germany

TABLE 3. Clones tested in Europe with Peruvian nematodes.

	Source of Inocula					
			Cuzco			
Source of Resistance	Otuzco	Huancayo	Paucart.	Chincheros	Puno	Areq.
S. andigenum	+	+	+	+	+	-
S. vernei 58.1642/4	+	+	±	+	+	+
62.33.3	±	-	±	-	+	-
66.1001.26	+	±	-			
S. kurtzianum 60.21.19	+	-	+	+	+	+
S. oplocense 1111	+	±				

Tested by Dr. H. Ross (1) in Germany and Dr. J. Kort (personal communication to J. Franco) in Holland.

TABLE 4. Parameter means of larvae measurements from Huancayo, Otuzco, Cuzco and Britain (given in microns).

	Source of larvae				
				England*	
	Huancayo	Otuzco	Cuzco	Pathotype A	Pathotype E
Stylet length	23.0±3.30	22.5±1.4	23.4±1.6	19.8±1.5	21.8±0.1
Dist.median valves to excretory pore	38.4±1.8	37.4±2.2	37.4±1.5	32.3±0.3	36.9±1.2
Body length	513.4±6.3	493.1±1+4.8	502.7+5.2	462.1±2.3	488.7+1.4

* Webley, 1070 (13, p. 108)

Number of larvae measured: Huancayo and Otuzco 40, Cuzco 30.

To further illustrate this point, comparison of morphometric measurements can be seen in Table 4.

All three populations of nematodes are closer to pathotype "E" than "A" in all three parameters; but the variation is very great. This is probably an indication that the field populations used were mixed pathotypes.

In order to do a more in depth study, single cyst studies, color difference and morphometric measurement studies are underway to help clear up this situation.

From a more practical point of view, we are mainly interested, not in how many pathotypes we have, but in whether we can find a broadly-based resistance that can be used to breed varieties resistant not only to the Peruvian pathotypes but also against other potato nematode populations in the potato growing areas of the world. As we have previously shown, all the existing tetraploids breeding lines were susceptible to at least two of the three populations.

Since it was discovered that S. andigenum CPC. 1673 is only resistant to pathotype "A", there has been a continuous search for resistance to more aggressive pathotypes among wild potato relatives. Quite a few have been found to have resistance. Some of those more often used in breeding programs are: S. kurtzianum, S. spegazzinii, S. oplocense and S. vernei. These species have been used to derive resistant lines. In general, S. vernei was found to be one of the most resistant species withstanding the attack of most nematode populations found in Europe. All these species, however, are difficult to breed with, as they are diploid plants and their resistance often is due to polygenes which are easily lost when crossing to a susceptible tetraploid. To illustrate this point: a genetic study by Plaisted and Peterson (8) at the diploid level with S. vernei showed at least two loci for resistance and a third one affecting the level of resistance. After two backcrosses with tetraploid varieties all the selected resistant lines were found to have retained only one main gene for resistance (10). Selection was conducted with pathotype "A". When these resistant lines were tested in Peru they were found to be susceptible: hence the importance of testing with aggressive pathotypes to insure that more factors for resistance are being retained at each backcross. Diploid material used as parental material for their resistance was also tested as it was of great interest to see how resistant these clones were prior to backcrossing. The results are summarized in Table 5.

TABLE 5. Number of diploid clones which were resistant to nematodes from Huancayo, Otuzco and Cuzco.

Source of Resistance	N° of Clones Tested	N° of Resistant Clones		
		Huancayo Inoculum	Otuzco Inoculum	Cuzco Inoculum
S. vernei	18	2	2	9
S. spegazzinii	20	2	2	6
S. neohawkesii	4	0	0	2
S. sanctae-rosae	5	2	1	1
	47	6	5	18

More cases of resistance were found in the diploid lines than in the tetraploid lines. However, only one of these 47 clones was resistant to all three populations. This was a clone of S. sanctae rosae. This species presents sterility and adaptation problems, so it will take hard work to use it as a source of resistance. In general, we believe that by crossing between different Solanum species which contain resistance one could obtain a broad resistance, and by testing with aggressive races it should be possible to retain these resistant genes after two or three backcrosses.

Another approach to finding resistance, taken by the Peruvian National Potato Program under Ing. Franco, was to test the germplasm collection from the National Potato Program in search for good resistance in a cultivated variety. This work has had some obstacles and thus the results are not clear. There are a few promising selections but further testing is needed before we can trust this data. It has become clear that resistance is not found often amongst these varieties and that the search will have to be thorough. An interesting sideline is that Howard and Cole have recently found a resistance to pathotype "E" in S. andigenum clone in England.

In summary, there seems to be more variability in Peruvian populations of the Heterodera than in Europe and the U.S.A. No nematode population that behaves like pathotype "A" was found.

There exists variability both within the potato cyst nematode and within wild and cultivated potatoes in Peru, providing good material for the search and development of better resistant varieties.

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MEJORAMIENTO DE LA PAPA EN ALEMANIA PARA RESISTENCIA A LAS DOS ESPECIES DE NEMATODE DEL QUISTE

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Para aquellas personas dedicadas a investigaciones de nematodes de quiste en papa, es una experiencia estimulante el estar aquí en La Molina, donde en 1956 Quevedo, Simón y Toxopeus (6) informaron que existían patotipos de este nematode que se sobreponían a la resistencia regida por el gene H1 de plantas ex-andigena C.P.C. 1673. Los investigadores holandeses van der Laan y Huijsman (5) obtuvieron los mismos resultados con una población colectada en Huancayo.

Ahora sabemos que estos autores no estaban trabajando con poblaciones de Heterodera rostochiensis, sino con otra especie aún no descrita de este nematode.

Sin embargo, pasaron muchos años antes de tener conocimiento de que el nematode del quiste en papa existía en dos especies. En 1966 Guile en Aberystwyth (3) dió un paso hacia esta realización cuando descubrió que poblaciones de nematodes se diferenciaban en la secuencia de la coloración durante el desarrollo del quiste hacia su madurez, en la cual todas las hembras maduras ("quistes") alcanzan un color marrón. En la mayoría de poblaciones europeas, las hembras pasan por una prolongada etapa de color amarillo dorado al desarrollarse en quistes, pero en poblaciones variantes, en esta etapa son blancas y cremosas. Mediciones comparativas del largo del estilete y de otros puntos diferentes en el cuerpo del nematode fueron hechas en la estación de Rothamsted y en el Instituto de Max-Planck en Colonia.

En el Cuadro 1, tomado de investigaciones del Ir. Bouwman y yo (1 - en esa publicación citamos más literatura) se muestra la situación actual. Quince poblaciones de varios países europeos como también de India y Perú fueron estudiadas para determinar el color principal de la hembra, pato-

CUADRO 1. Color de hembras en desarrollo, medidas morfométricas de las clones diferenciales.

Poblaciones	Color principal de la hembra en desarrollo	Largo del Estilete	Distancia: de nódulos basales del estilete hasta el terminal anterior de la larva	Variedad Susceptible *S. tuberosum*
Neersen	d	20.2	23.8	+
Mierenbos	d	20.9	22.9	+
Hohenried	d	21.2	22.2	+
Obersteinbach	d	20.9	23.6	+
Pont	d	20.7	22.8	+
Harmerz	d	21.4	23.1	+
promedio		20.9 ± 0.19	23.1 ± 0.16	
Duddingston	c	21.7	23.1	+
Frenswegen	b	21.6	25.3	+
P2-4	b	21.9	24.3	+
MBB	b	22.1	25.2	+
Huancayo	c	23.2	25.5	+
Cuzco	b	23.4	25.5	±
Nilgiris	b	21.9	25.0	+
Chavornay	c	22.4	25.7	+
Otuzco	b	22.5	25.9	
promedio		23.3 ± 0.21	25.1 ± 0.29	

d = dorado; c = crema; b = blanco; + = 16 o más quistes; - = 0-5 quistes;

larvas y patogenicidad de 15 poblaciones del nematode del quiste en papas en

Variedad Resistente ex-*S. andigena* CPC 1673, gene H1	Retrocruce *S. tuberosum* con ex-*S. spegazzinii*, gene Fb	Retrocruce *S. tuberosum* con ex-*S. vernei* línea 6041	Retrocruce *S. tuberosum* con ex-*S. oplocense*
–	–	–	–
–	–	–	
±	–	–	–
+	–	–	–
+	–	–	–
+	–	–	–
+	+	–	±
+	+	–	–
+	+	+	–
+	+	±	±
+	+	±	–
+	+	–	
+	+	+	
+	+	+	+
+	+	+	+

± = 6–16 quistes.

genicidad y morfometría. Las poblaciones peruanas fueron generosamente enviadas por el Ing. Javier Franco Ponce.

Se puede observar que las poblaciones con la fase dorado larga, tienen las mediciones más cortas que los tipos con hembras de fase blanca y crema. Estas diferencias son, sin embargo, pequeñas.

Las diferencias en patogenicidad son muy importantes y muchos puntos oscuros referentes a las relaciones entre poblaciones y genes resistentes se han aclarado; ahora se pueden emprender cruzamientos para resistencia con mejor comprensión y planificación.

Hemos encontrado que generalmente los genes de resistencia a *H. rostochiensis sensu strictu*, en especies silvestres, son más numerosos que los genes que reducen la formación de quistes en los tipos cremosos o blancos.

Por lo menos se ha encontrado un gene que diferencia entre los tipos dorados y blancos, este es el gene Fb de *S. spegazzinii* (antes *S. famatinae*). Muchas otras especies de *Solanum* entre las plantas hospederas también diferencian los dos tipos, pero los genes aún no han sido caracterizados.

Pero aún ésto no fué suficiente justificación para la separación del nematode en dos especies. Otro aspecto fue, como demostraron Trudgill y Carpenter (11), que los patrones cromatográficos de proteínas diferenciaban los dos tipos, pero aún en forma más convincente, Ir. Bouwman demostró en Colonia que cruces entre nematodes de poblaciónes distintas en su color no daban origen a huevos fértiles. Bouwman infectó las raíces de pequeñas plantas con pares de larvas; una de una población dorada y la otra de una población blanca. La formación de quistes demostraba que la copulación había ocurrido. Cada quiste fue puesto con una planta susceptible, pero no se formaron nuevos quistes, demostrando que los huevos eran estériles. Por otro lado la fertilización entre diferentes poblaciones doradas o entre diferentes blancas sí producían quistes fértiles.

Es por esto que ahora es claro que existen dos especies. La descripción de la nueva especie la está preparando el Dr. Stone de Rothamsted, y será publicada en Nematologica Vol. 18, N° 4, a fines de este año.

El Cuadro 2 muestra la distribución de las dos especies según trabajos realizados en Rothamsted y Colonia. Ambas especies fueron halladas en la mayoría de los países europeos. En India sólo se ha encontrado la especie nueva, mientras que los EE.UU. de N.A. hospeda hasta la fecha solamente

H. rostochiensis. Respecto a América Central y Sur, colecciones de Panamá, Venezuela y Bolivia resultaron pertenecer a H. rostochiensis mientras las tres colecciones del Perú pertenecían a la nueva especie. Información detallada de la distribución de ambas especies por el mundo es deficiente. Sin embargo, sería imprudente restringir el programa de fitomejoramiento a una sóla especie, en un país donde hasta la fecha, solamente se haya encontrado una especie. Como es ya generalmente conocido, la expansión de las comunicaciones tiende a distribuir todo tipo de parásitos rápidamente alrededor del mundo, siendo la adecuación al nuevo ambiente el factor limitante para el establecimiento del parásito. Es, sin embargo, casi seguro que ambas especies pueden vivir dondequiera que se cultiven papas.

CUADRO 2. La ocurrencia de ambas especies de nematodes de acuerdo a investigaciones en Rothamsted y Colonia.

	H. rostochiensis	Species nova
República Federal de Alemania	+	+ (muy pocos)
República Democrática Alemana	+	+ (muy pocos)
Holanda	+	+
Noruega	+	+ (pocos)
Islandia(1)	+	
Gran Bretaña	+	+
Suiza	+	+
Italia		+
Grecia	+	
India		+
Canadá	+	
E.E.U.U. de N.A.	+	
Panamá	+	
Venezuela	+	
Perú		+
Bolivia	+	

(1) Comunicación personal de Einar J. Sigeirsson.

Ahora debemos considerar la obtención de variedades resistentes al nematode. La situación general es como sigue: En primer lugar, ambas

especies pueden ser subdivididas en patotipos de patogenicidad distinta. Muchos genes presentes en especies silvestres reducen hasta cierto punto la formación de quistes de ambas especies. Hasta el momento no se ha encontrado ningún gene que pueda reducir hasta cerca de cero el número de quistes de todos los patotipos. Sin embargo, esto no quiere decir que tal gene no podría existir. La búsqueda entre especies silvestres y primitivas sigue siendo una tarea muy importante para el futuro.

Pienso que esta tarea es especialmente apropiada para el Centro Internacional de la Papa, ya que el banco de genes del Centro puede proveer el material y todos los países que cultivan papas en el mundo podrían aprovechar de los resultados de este proyecto.

Mientras una resistencia general no sea disponible, tenemos que considerar la acción de los genes presentes que existen en el mundo en las líneas de cruce con respecto a las diferentes poblaciones de las dos especies.

Casi todas las variedades resistentes de Europa y Norte América poseen el gene mayor H1 de S. andigena C.P.C. 1673, un cultivar Andino de la región de La Paz. El Cuadro 1 demuestra que la acción de este gene no es muy amplio. Aunque sigue siendo cierto que reduce la formación de quistes de una gran mayoría de poblaciones de H. rostochiensis en Europa, otras poblaciones de H. rostochiensis pueden vencer la efectividad de este gene.

Una acción más amplia puede ser atribuída al gene Fb de ex-S. spegazzinii, ya que ninguna población de H. rostochiensis pudo sobrepasar esta resistencia hasta la fecha (1,7,8). Híbridos retrocruzados están ahora muy avanzados. Algunas líneas han entrado a ensayos de variedades y con toda seguridad aparecerán como variedades dentro de un tiempo. Sin embargo, no se ha encontrado resistencia contra la especie nueva.

Otra especie, S. vernei, también es importante en el mejoramiento para resistencia a este nematode. Se está usando esta fuente de resistencia en Holanda, Gran Bretaña, E.E.U.U. de N.A. y Alemania. No hay duda que S. vernei contiene genes mayores equivalentes a los ya mencionados - ver también Huijsman (4) y Scurrah (10). Las segregaciones genéticas en mi material han sido muy complicadas y a la vez enigmáticas. Ahora pienso que con las siguientes suposiciones, aclaro lo referente a la naturaleza de esta resistencia:

1. Existen genes principales que actúan principalmente contra H. rostochiensis y otros que actúan principalmente contra la especie nueva. El-

primer grupo de genes, sin embargo, también influye en la formación de quistes de la nueva especie y el segundo grupo vice-versa.

2. No se puede esperar que todos los distintos genes mayores reduzcan el número de quistes a cero o casi cero. H_1 y Fb son genes de este tipo con efectividad muy alta. Pero en S. vernei y otras especies silvestres encontré claramente genes segregantes que permitían una formación promedio de quistes de 5-10 y no de 0, 1, ó 2 en el "método de evaluación" de raíces en maceta volteada (8). Estos pueden considerarse genes débiles.

3. Existen polygenes para resistencia. Aunque el nivel de resistencia está controlado principalmente por genes mayores, los polygenes ejercen cierta influencia en la formación del quiste con una dirección positiva o negativa. Así en el caso de un gen "débil" para resistencia, solamente aquellas pocas plántulas que están acompañadas por polygenes favorables, muestran una reducción de quistes hasta un nivel necesario.

¿Qué es necesario? En Alemania, Holanda y otros países una variedad es considerada resistente cuando una vez pasado el cultivo; el número de huevos y larvas que sobreviven en el suelo es reducido a un nivel más bajo que al sembrar cualquier otro cultivo no hospedero que no sea papa. Sin embargo, esto sólo sucede cuando una variedad muestra de 0 a 3 quistes en el método de evaluación en maceta volteada ("root ball").

En S. vernei solamente he hallado genes mayores contra H. rostochiensis. Algunos de estos genes son muy efectivos reduciendo el número de quistes a casi cero. Ellos ejercen un efecto adicional sobre algunas poblaciones de la especie nueva, pero este efecto es tan débil que rara vez se encuentra un segregante proveniente de un retrocruce con 0 a 3 quistes. Un segregante con esa característica debe entonces poseer polygenes favorables acompañantes.

Generalmente lo mismo también es cierto para híbridos de S. oplocense. Los experimentos demuestran que es posible que S. oplocense contenga genes con una acción principal contra la nueva especie, pero estos genes tienen solamente una efectividad débil, ya que se obtienen muy pocos segregantes con menos de 3 quistes.

Hemos probado las reacciones de mis líneas de cruzamiento con las tres poblaciones peruanas de la especie nueva. Estas poblaciones se encuentran entre las que poseen el mayor grado de agresividad, y la única que mos-

tró resistencia contra todas las poblaciones fue un retrocruce 1786 de S. oplocense x S. tuberosum, pero ocurren muy pocos segregantes con un nivel de resistencia tan alto. Es por esto que S. vernei y S. oplocense no son muy satisfactorias como fuentes de resistencia.

Hay que tomar un nuevo enfoque. Debemos encontrar un gene que actúe principalmente contra la especie nueva y que tenga una efectividad fuerte. Dunnett (2) fue el primero en descubrir un gene contra esta especie en S. multidissectum. Este gene H_2 no impedía el establecimiento de H. rostochiensis, pero fue efectivo contra poblaciones como la de Duddingston la cual ahora sabemos pertenece a la especie nueva. Este gene H_2, sin embargo, es muy débil y poco efectivo contra la mayoría de poblaciones de la nueva especie y debemos buscar en otros lugares.

Huijsman y yo en 1969 (9) publicamos nuestros resultados referentes a las reacciones de 63 especies silvestres, de más de 200 lugares de origen, contra poblaciones de H. rostochiensis y de la especie nueva. Este trabajo nos puede guiar hacia donde sería más útil la búsqueda de genes resistentes más efectivos contra la especie nueva. Encontramos que las siguientes especies tenían el tipo de reacción de S. multidissectum: S. bukasovii, S. canasense, S. gandarillasii, S. gourlayi, S. rechei, S. sandemanii y S. sparsipilum. Otra especie no descrita hasta hoy puede ser añadida. El Ing° Pedro López y yo la coleccionamos en el valle de Churín cerca de Lamacancha, Perú.

Perú es especialmente apropiado para buscar y mejorar la resistencia en papas contra la nueva especie de Heterodera, porque las 3 poblaciones peruanas son las más agresivas que conocemos. Todas las líneas resistentes a estas poblaciones también lo son hasta cierto grado a otras poblaciones de la nueva especie.

El trabajo del Centro en resistencia a nematode, es por esto, de gran interés para los mejoradores de papa, dondequiera que trabajen. Espero que el Centro sea fructífero en su tarea para el beneficio de mucha gente.

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SEVENTH SESSION

BREEDING FOR BACTERIAL WILT OR BROWN ROT (*Pseudomonas solanacearum*) RESISTANCE

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RESISTENTES A
PSEUDOMONAS SOLANACEARUM
BR - 61 - 5
RESISTENTES A
PSEUDOMONAS SOLANACEARUM
BR - 69 - 50
RESISTENTES A
PSEUDOMONAS SOLANACEARUM
BR - 66 - 3
RESISTENTES A
PSEUDOMONAS SOLANACEARUM
BR - 63 - 65
RESISTENTES A
PSEUDOMONAS SOLANACEARUM
BR - 63 - 76

PROGRESOS EN LA SELECCION DE RESISTENCIA A LA MARCHITEZ BACTERIANA EN EL PERU

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La enfermedad de la marchitez bacteriana (Pseudomonas solanacearum) está causando considerables daños a cultivos de papa en la zona norte del Perú, y constituye una grave amenaza para el futuro del cultivo en el país.

Un programa para seleccionar clones con altos niveles de resistencia y la utilización de ellos en un programa de mejoramiento fue iniciado en 1970. Aproximadamente 950 clones han sido evaluados bajo condiciones de campo, 540 de los cuales proceden de la colección del Banco de Germoplasma del CIP-Programa Nacional de Papa y los otros 410 consisten de S. phureja, híbridos de S. phureja x S. tuberosum e híbridos de (S. phureja x S. tuberosum) x S. tuberosum del programa internacional de mejoramiento para esta enfermedad de la Universidad de Wisconsin (que tuvo sus inicios en cooperación con el ICA de Colombia), que ahora se realiza en coordinación con el CIP.

La investigación se ha venido conduciendo en un terreno naturalmente infestado, ubicado en la localidad de Huambos (Departamento de Cajamarca) a 2,350 m.s.n.m. El procedimiento empleado y la resistencia encontrada se dan a conocer en el presente trabajo.

La siembra del material se hizo en forma randomizada, empleándose el diseño Block Completamente Randomizado con 6 repeticiones y en dos épocas del año.

La evaluación del material se efectuó en base a la sintomatología que desarrollaron las plantas en el transcurso de su período vegetativo. Se efectuaron 5 calificaciones: 3 durante el desarrollo vegetativo, 1 al momento de la cosecha y una última 20 días después de cosechado el material.

La selección para resistencia se hizo en base al total de plantas por

CUADRO 1. Clones de papa del programa de Wisconsin que no mostraron infección en tres campañas.

Clones	Origen
E - 88	
6 - 11	
A - 1	
8 - 34	
BR 60 - 54 (4)*	ICA - Purace x 8 - 14
BR 61 - 5 (5)	ICA - Purace x A - 1
BR 62 - 3 (2)+	
BR 62 - 5 (2)+	Atzimba x 8 - 9
BR 63 - 3 (3)	
BR 63 - 60 (4)	
BR 63 - 65 (1)+	
BR 63 - 70 (4)	
BR 63 - 74 (3)+	
BR 63 - 75	
BR 63 - 76 (2)+	
BR 63 - 82 (4)	
BR 63 - 96 (4)	Atzimba x A - 1
BR 65 - 5 (4)	Greta x V - 7
BR 66 - 3 (5)	59 - 908 - 22 x 3 - 7
BR 69 - 24 (5)	
BR 69 - 32	
BR 69 - 50 (3)	
BR 69 - 84 (3)+	Anita x A - 1
BR 73 - 4 (3)+	Anita x T - 2

* Grado de resistencia a P. infestans Toluca, México (1 Resistente, 5 susceptible) dados entre paréntesis.

\+ Clones que han sido seleccionados en Colombia.

clon que permanecieron libres de infección; los clones seleccionados fueron puestos en observación hasta su ingreso a la próxima campaña. Clones que desarrollaron síntomas durante este período de observación fueron eliminados. Se han obtenido 24 clones sin infección al término de 3 campañas consecutivas. Se presentan estos clones del programa de mejoramiento de Wisconsin en el Cuadro 1.

SELECCION Y MULTIPLICACION DE VARIEDADES DE PAPA CON RESISTENCIA A "DORMIDERA" (Pseudomonas solanacearum E.F. Smith) EN COLOMBIA

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En Colombia se siembran unas 100,000 hectáreas de papa, en su mayoría en zonas altas (2,600-3,500 m.s.n.m.), pero también se cultiva en alturas inferiores, llegando a sembrarse entre 1,500 y 1,800 m.s.n.m. en climas cafeteros de 17 a 21°C. Se estima que en estas zonas se cultiva un 10% de la producción nacional y es en estos sitios en donde persiste el problema de la enfermedad bacteriana conocida por los agricultores Colombianos con el nombre de "dormidera", causada por Pseudomonas solanacearum.

Ramón Mejía Franco habla de "dormidera" desde 1939, quien la observó en Antioquía, pero los estragos mayores que se presentaron fueron por los años 1959 a 1961, cuando se iniciaba la multiplicación y distribución de la primera variedad obtenida por el Programa de Papa con el nombre de Diacol Monserrate. Fue en esta época en que se presentó esta enfermedad en forma grave y alarmante, especialmente en cultivos de multiplicación en los cuales se había cortado la semilla para aumentar rápidamente el material. Pero al detectarse la endemia, se frenó su distribución.

En la actualidad, debido a una rotación de cultivos y uso de semilla entera, en los terrenos en que se presentó, la bacteria ha desaparecido y se puede decir que en la Sabana de Bogotá (que se encuentra a 2,640 m.s.n.m. y una temperatura promedio de 13.8°C) no hay dormidera e igualmente se puede afirmar para las zonas paperas que sobrepasan esta altura, las cuales constituyen la mayoría de los suelos dedicados al cultivo de la papa. En vista de la situación anterior, H.D. Thurston, Director del Programa de Papa de ese entonces (1965), junto con sus colaboradores iniciaron una prueba de todo el material de la Colección Central Colombiana (CCC) que constaba de 1061 cultivares pertenecientes a las especies Solanum tuberosum sp. andigena, Solanum tuberosum sp. tuberosa, Solanum phureja, algunos híbridos de Solanum tuberosum x Solanum andigena y algunas especies silvestres.

Estos trabajos se llevaron a cabo en los invernaderos del Centro Nacional de Investigaciones Agropecuarias de Tibaitatá con una temperatura promedio de 17.5°C. El método usado fue de inoculación con jeringa y las lecturas se tomaron 30 días después en base a la siguiente escala de clasificación: 0 = sin síntomas; 1 = una hojas marchita; 2 = 1/3 de hojas marchitas, 3 = 2/3 de hojas marchitas; 4 = todas las hojas marchitas; 5 = planta muerta.

De todo el material inoculado se destacaron por su alta resistencia las siguientes variedades de la CCC:1339 (Criolla), 1350 (Limona o amarilla), 1386, 1388, 1395 y 1149 (Chaucha negra). Este material seleccionado que se puede considerar como la mejor fuente de resistencia a la bacteria, se envió a la Universidad de Wisconsin y se aprovechó también en el Centro Nacional de Investigaciones Agropecuarias de Tibaitatá para el proyecto de Mejoramiento.

En 1968 enviaron de Wisconsin más de 1,200 híbridos para ser evaluados en zonas donde la enfermedad es frecuente. Este material se dividió; una parte se sembró en la meseta de Popayán (Departamento del Cauca) a una altura de 1,800 m.s.n.m. y una temperatura promedio de 17°C y la otra se sembró en Medellín (Departamento de Antioquía) a una altura de 2,200 m.s.n.m. y una temperatura promedio de 21°C.

En las primeras siembras se seleccionó material, descartando aquellos clones que resultaron con susceptibilidad a Phytophthora infestans, poco rendimiento y otros porque presentaron síntomas de Pseudomonas solanacearum. De los 1,200 clones sembrados inicialmente se seleccionaron los siguientes 38, que tienen buenas características del tubérculo, buen rendimiento, resistencia a Phytophthora infestans y son casi inmunes a Pseudomonas solanacearum:

1/3	5/6	9/6	H/7	N/78	P/9	U/2	X/6
2/3	7/5	9/7	H/8	M/12	P/11	U/12	Y/51
3/1	7/6	9/15	H/93	P/1	P/13	V/4	Z/13
3/2	7/9	G/5	K/4	P/3	T/5	V/15	
5/5	7/10	G/62	N/10	P/7	T/3	W/1	

Una parte de este material seleccionado se trasladó al Programa de Fitopatología en la Estación Experimental "La Selva" (Medellín, temperatura de 16°C) Antioquía, donde se sembró en un lote aislado e infestado artifi-

cialmente con la bacteria. Los síntomas de marchitez fueron bastante notorios en muchas de las líneas seleccionadas anteriormente en Popayán y en Medellín. De este ensayo se seleccionaron por no presentar síntomas de Pseudomonas solanacearum los clones que se presentan en el Cuadro 1. Parte de este material se encuentra en la actualidad sembrado para su multiplicación en el Centro Nacional de Investigaciones Agropecuarias de Tibaitatá (2,640 m.s.n.m.) y en la Estación Experimental San Jorge a una altura de 3,200 m.s.n.m.

En 1970 se recibieron 672 clones de Wisconsin y después de dos cosechas se seleccionaron 34. Este material fue sembrado, cosechado y seleccionado en el presente año. En la actualidad se tienen en bodega unos 24 clones, cuyos números, porcentaje de ataque presentado, color de la piel y tamaño se anotan en el Cuadro 2.

Del material híbrido, enviado desde Tibaitatá a Popayán se han seleccionado como promisorios los siguientes híbridos derivados del cruce ICA-Puracé x CCC 1449 Chaucha Negra (*Solanum phureja*): 66-337-18, 67-337-22, 67-337-28 y 67-337-45, y además del cruzamiento de ICA-Guantiva x CCC 1449, los híbridos 67-343-5, 67-343-9 y 67-343-10.

CUADRO 1. Clones seleccionados en la Estación Experimental La Selva.

Nº de Colección	Tamaño	Forma	Prof. Ojos	Color Piel	Color Carne
2/3	Mediano	Regular	Mediano	Rosada	Crema
3/1	Mediano	Buena	Mediano	Crema	Crema
3/2	Mediano	Buena	Superf.	Crema	Crema
5/5	Mediano	Buena	Superf.	Crema	Crema
7/9	Mediano	Buena	Superf.	Crema	Crema
N/10	Mediano	Buena	Superf.	Crema	Crema
P/13	Mediano	Regular	Superf.	Púrpura	Crema
P/7	Mediano	Buena	Superf.	Púrp.Crema	Crema
P/9	Mediano	Regular	Mediano	Púrpura	Crema
7/6	Mediano	Regular	Mediano	Crema	Crema
7/10	Mediano	Buena	Superf.	Crema	Crema

CUADRO 2. Características de clones seleccionados en dos campañas.

N° de Colección	% Plantas Enfermas	Tamaño	Color de la Piel
60-43	5%	Pequeño	Rosado
60-68	10%	Mediano	Rosado crema
60-85	20%	Pequeño	Rosado
62-1	40%	Grande	Blanco
63-1	10%	Grande	Blanco
60-63-51	20%	Grande	Blanco
63-93	5%	Pequeño	Blanco
63-155	5%	Pequeño	Blanco
65-9	5%	Pequeño	Rosado
69-6	5%	Pequeño	Rosado
69-11	10%	Pequeño	Rosado
69-13	5%	Grande	Rosado
69-16	30%	Grande	Rosado
69-17	15%	Pequeño	Rosado
69-39	10%	Pequeño	Rosado
69-46	5%	Pequeño	Rosado
69-47	10%	Grande	Rosado
69-59	5%	Pequeño	Rosado
69-84	5%	Mediano	Rojo
69-86	5%	Pequeño	Rojo
69-101	10%	Pequeño	Rosado
70-55	15%	Pequeño	Rosado
71-5	30%	Pequeño	Blanco
73-3	20%	Pequeño	Púrpura

THE SIGNIFICANCE OF BACTERIAL WILT IN THE DEVELOPMENT OF POTATOES IN KENYA

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Bacterial wilt does not constitute as great a threat to potato development in Kenya as was apparent in the early 1960's. The improved situation is attributed to the emergence of high altitude potato production on settlement farms where wilt is not a problem. Factors affecting the severity of wilt outbreaks are considered. The future control of wilt is discussed and research priorities are outlined.

Introduction

A major effort has been launched in Kenya to develop potatoes as a food crop. Of the pathological problems in this programme blight (caused by *Phytophthora infestans*) is the most important. In recent years bacterial wilt (caused by *Pseudomonas solanacearum*) has also attained some importance as a disease limiting potato yields.

Bacterial wilt was first recorded in Kenya by Nattrass (1945), although it was probably introduced some years previously. Wilt subsequently became widespread and caused increasing losses. By 1963 the situation had become so alarming that Robinson and Ramos (1964) concluded that in the absence of resistant varieties potato cultivation in Kenya would decline to insignificance. This is an opportune moment to review the importance of wilt in Kenya and to reconsider methods of controlling the disease.

The disease

Bacterial wilt of potatoes in Kenya is caused by the strain of *P. solanacearum* variously known as race 3 (Buddenhagen et al., 1962) and biochemical type 2 (Hayward, 1964). This strain has a restricted crop host

range (potato and tomato) but, in Kenya, is known to attack some weed hosts. Thurston (1963) has shown that this strain can cause disease at lower temperatures than other strains and this has been confirmed in Kenya (Ramos, personal communication). Apart from this tolerance of lower temperatures the disease caused by this strain is very similar to the brown rot of potatoes long known in the U.S.A. and other parts of the world (Kelman, 1953).

The systems of potato growing in Kenya

To understand the wilt situation in Kenya it is necessary to understand the systems of potato growing. Most potatoes are grown between 4,500 and 8,500 feet. This range of altitude can be considered as two zones: one between 4,500 and 6,500 feet and the other between 6,500 and 8,500 feet. The lower zones is occupied by a large number of traditional family small holdings, varying in size from 1 to 20 acres. Maize and beans are the principal food crops, and coffee or tea the main cash crops, but potatoes have also been grown on a small scale for many years. Standards of potato cultivation vary considerably. In some areas spraying against blight and the use of fertilizers have become general, and there is a growing awareness of the importance of good seed. In other areas standards remain poor.

At the higher elevations potatoes are grown on recently established settlement farms from 6 to 30 acres in size. Here potatoes constitute a major food and cash crop and their importance is reflected in generally higher standards of husbandry. Potatoes are also grown at high altitude Forest Stations where forest workers are allowed to interplant young trees with vegetables. This shifting system of cultivation in remote forest areas has not been conducive to the development of good farming standards.

A small number of large, highly capitalised farms, at high and low elevations also produce potatoes, and although their output is relatively small it is important because it includes the bulk of the supply of certified seed.

During the last eight years settlement farms have attained considerable importance in potato growing with the result that emphasis has shifted from low to high altitude potato production.

Present status of bacterial wilt in Kenya

Wilt is much more important in the lower than the higher zone. In the traditional areas wilt can be found in 2 out of 3 fields, although only

among the worst farms does it often exceed an incidence of 5%. Wilt is usually more serious in places most remote from extension services and supplies of healthy seed. In the high settlements and in the forest areas wilt is generally unimportant. Sporadic outbreaks do occur but the losses caused are minor. Nor is wilt a problem on the large commercial farms.

Thus wilt remains a moderately important disease in the traditional farming areas but has failed to become established in the high altitude settlements and Forest Stations. The substantial expansion of potato growing in the settlement schemes has therefore considerably reduced the overall impact of this disease in Kenya potato production during the last decade.

The most important factors influencing wilt in Kenya are: climate, the level of seed infection; and the level of soil contamination. These are discussed below.

Effect of Climate on bacterial wilt

Bacterial wilt is a disease of tropical and sub-tropical zones and it is to be expected that with increasing altitude in the tropics climatic factors would become limiting. In Kenya bacterial wilt epidemics are retarded as soil temperatures drop from 22°C and, below 14°C, no wilting occurs (Ramos, personal communication). This temperature effect partly explains the reduced importance of wilt at higher altitudes. However, wilt does occur even at 9,000 feet when infected tubers are planted, so that the failure of wilt to become established is probably also due to the effect of climate on the soil phase of the disease. Thurston (1963) reported a ceiling of 7,500 feet for bacterial wilt of potatoes in Colombia caused by a strain similar to that in Kenya.

Bacterial wilt is always more serious in Kenya when rainfall is high. It is well known that high soil moisture favours wilt (Kelman, 1953) and, in Kenya, the effect seems to be one of enhanced plant-to-plant spread and enhanced survival of the pathogen in the soil (see below).

Effect of seed-borne wilt

Recent work has shown that although potato tubers infected by *P. solanacearum* can be very resistant to rotting in store, the plants growing from them readily succumb to the pathogen in the field. This is a most dangerous aspect of wilt because tubers from an affected crop which are outwardly healthy

produce diseased plants in the next crop.

In the traditional areas most potato seed is locally obtained from shops and markets. Some of this seed comes from the settlement areas of Meru, Nyandarua and Nyeri and is largely wilt-free, but there is a continuous cycling of locally produced seed which is usually wilt-infected. The potato growers in these areas are therefore at the mercy of the seed they buy.

The settlement areas are mostly self-sufficient in seed potatoes and through the primary introduction of wilt-free stocks the disease has been largely excluded. Indeed, in Nyandarua District, which is composed almost entirely of highland settlements, there is legislation forbidding the introduction of all but certified seed.

At Forest Stations potato growers continue to enjoy the advantage of wilt-free soil, but there is no deliberate policy of wilt-free seed. However most of the seed comes from adjacent high altitude areas and is usually saved for several generations. Forest potato growers are thus largely protected from the introduction of wilt with their seed potatoes.

Outbreaks of wilt in the settlement and Forest Stations have always been associated with seed introduced from lower elevations.

Soil-borne wilt

Robinson and Ramos (1964) believed that once contaminated with wilt land remained so for many years. The evidence on this is conflicting. Unfortunately since very little seed is above suspicion, it is generally impossible to know whether infection came from the soil or from the seed. Most of the wilt seen in recent surveys was on land that was formerly wilt-free, and was therefore due to seed-borne inoculum. That the pathogen does survive in the soil under some circumstances is confirmed by the occurrence of wilt in potatoes grown from imported Scottish seed and in tomatoes. However, there is no evidence for the wholescale spoiling of land through wilt contamination as predicted by Robinson and Ramos (1964). Soils in Kenya, especially at lower altitudes, are subject to intense desiccation during dry seasons and P. solanacearum is known to be very sensitive to de hydration. This may explain why the soil-borne phase of the disease is not as significant in Kenya as elsewhere and why wilt becomes more important in wet years.

The practice of rotating wilt-infested fields is widely used and may

be another reason for the relative unimportance of soil-borne inoculum.

The control of wilt in Kenya and research priorities

Wilt has occurred sporadically in all the settlement areas but has never become established. It seems safe to predict that, given the continuing use of wilt-free seed, the disease will never become a problem in the higher potato growing areas.

Since, in the lower areas, most wilt results from planting diseased seed, a great deal can be achieved by encouraging the use and improving the availability of wilt-free seed. Ultimately this may be effected through a seed certification system, but in the near future it remains the responsibility of extension staff to establish contacts between growers producing wilt-free potatoes and those wishing to buy them. By encouraging the saving of seed, wilt - free stocks can be maintained as in the settlement areas.

Attempts to control wilt through the use of healthy seed will founder if the seed is planted on heavily contaminated land. Hence one of the more important projects in bacterial wilt research in Kenya is a study of the persistence of soil-borne inoculum at different altitudes and under different rotation regimes.

Although the need for resistant varieties is not as great as was formerly believed, the Potato Research Section in Kenya hopes to produce varieties with some resistance to wilt. It is intended to exploit the resistance found in the species *Solanum phureja* by Thurston (1965) and Robinson (1968), and that occurring in hybrids of *S. phureja*, *S. demissum*, *S. microdontum* and *S. tuberosum* bred by Dr. W. Black which have blight resistance and other qualities. The greatest pathological problem in the programme is to devise methods for selecting resistant individuals from progenies. No high level of resistance has been found in the material under Kenyan conditions, and the difficulty lies in selecting seedlings which have only moderate levels of resistance without killing them in the process.

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DEVELOPMENT OF POTATO CLONES WITH RESISTANCE TO BACTERIAL WILT[1]

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The serious disease problem that bacterial wilt (Pseudomonas solanacearum E. F. Sm.) causes on potatoes in tropical and subtropical areas of the world is well known. Adequate levels of resistance on which to base potato breeding programs were not known until the discovery by Thurston and Lozano (1968) that certain Colombian clones of S. tuberosum Gp. Phureja had high levels of resistance. Their discovery stimulated renewed interest in breeding for resistance.

A project to study bacterial wilt was initiated in Wisconsin early in 1967. The objectives were to detect sources of resistance, to investigate the inheritance of resistance, and to develop germ plasm that would be useful to potato breeding projects in countries where bacterial wilt was a problem. The project has been funded by grants from the Rockefeller Foundation to the University of Wisconsin.

All tests to determine disease reaction in Wisconsin have been conducted in the greenhouse and in growth chambers. To obtain reproducible results, growth chambers had to be utilized although they are expensive to operate and the number of plants that can be tested is restricted. The details on the testing procedures have been published by Sequeira and Rowe (1969).

The plant material that was used as the basic source of resistance

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[1] Cooperative investigations of the Agricultural Research Service, U.S. Department of Agriculture and the College of Agricultural and Life Sciences, University of Wisconsin, Madison. Supported in part by grants from the Rockefeller Foundation.

was from the Colección Central Colombiana. These Phureja stocks were provided by Dr. H. David Thurston, first in the form of open-pollinated seed, and later as tubers after these clones cleared through U.S. quarantine procedures.

The open-pollinated seed was grown and an initial screening with isolate K-60 isolated 20 resistant clones. After a tuber increase was obtained, these clones were tested against 10 isolates of P. solanacearum. The reaction of the individual clones ranged from resistance only to isolate K-60 up to resistance to all isolates (Sequeira and Rowe, 1969).

The most resistant clones were used in crosses with each other and with 24-chromosome clones of Gp. Tuberosum. Progeny from these crosses provided the start of efforts to study the inheritance of resistance and to develop germ plasm of potential value in potato improvement. Data from the initial crosses indicated that resistance was a dominant trait that was transmitted to a high frequency of the progeny. Extensive tests in the growth chamber have led to a hypothesis that resistance is controlled by few genes that react specifically with certain isolates or groups of isolates (Rowe and Sequeira, 1970; Rowe, Sequeira and Gonzalez, 1972).

During the time that tests were being conducted in the growth chamber to study some basic aspects of disease reaction, germ plasm to test the levels of resistance was developed. Crosses were made at Sturgeon Bay and clones were produced in the greenhouse. These hybrids, both seed and tubers, were distributed to several countries, primarily to Costa Rica and Colombia initially, for tests under field conditions.

Table 1 lists the countries that have received stocks from Wisconsin and the cooperators who have been responsible for conducting the field tests. The results that these men made available to us were used to determine what parents to utilize in further crosses. Their cooperation has been an essential part of the program. This list also illustrates the world-wide interest in finding useful resistance to P. solanacearum.

Seed of 223 crosses, tubers of 639 clones and over 8,000 tubers of individual seedlings have been distributed during the past five years (Table 2). Distribution has slowed somewhat in the last two years because we decided not to produce any new material until good field evaluation data became available for the stocks that had already been distributed. Since, in most instances, only a limited amount of material could be sent, it has taken several growing seasons at each specific location to produce enough material to obtain reliable results.

TABLE 1.- Countries where potato hybrids have been screened for resistance to *P. solanacearum*

Country	Cooperator	Country	Cooperator
Brazil	A. Drummond Raúl Ribeiro	Indonesia	H. Vermeulen
Ceylon	Cedrick R. de Vaz	Kenya	R. A. Robinson
Colombia	Nelson Estrada	Mauritius	R. Antoine
Costa Rica	Luis C. Gonzalez	Nigeria	Dale Suchomel
Fiji Islands	G. R. T. Levick J. B. D. Robinson Peter Thompson	Peru	Isaías Herrera E. R. French
Honduras	Salvador Quiroz	Philippines	J. C. Acosta L. T. Empig E. C. Quisumbing
India	Pushkarnath		

TABLE 2.- Distribution of potato seed and tubers for screening for resistance to *P. solanacearum*

			Tuber families	
Year	Seed	Clones	Number	Seedlings
1968	36	53	92	4871
1969	47	23	91	2001
1970	20	175	30	1257
1971	83	191		
1972	37	197		
Totals	223	639	213	8129

The general pedigrees of the potato hybrids that have been distributed are shown in (Table 3). At first the Phureja clones that were resistant in the greenhouse were intercrossed and crossed with 2x and 4x Tuberosum (Tbr). Hybrid clones that were reported to have resistance in the field have been added to the crossing program as they have become available. Theoretically, the Phureja hybrids should have the highest levels of resistance but it has been difficult to get field performance data on these hybrids. Because of the small tubers and the lack of dormancy, most of these clones did not do well in field tests.

Parents of the seedling tubers that were distributed in 1968 were the resistant selections of Phureja, and Phureja x 24-chromosome Tuberosum clones, and both 24-and 48-chromosome Tuberosum (Table 4). The 2x Tbr were hybrids that had been selected at Sturgeon Bay from inter-haploid crosses. The 4x Tbr were the U.S. cultivars Katahdin and Chippewa and certain virus-resistant seedlings that had been introduced from Germany. The crosses with 2x Tbr would be expected to give almost all diploid or 24-chromosome progeny while the crosses with 4x Tbr would give almost all 4x progeny.

Although most of the clones that were distributed were diploids, a majority of those that were selected came from the tetraploid populations (Table 4). The manner in which the 2n gametes are formed in the 2x-4x crosses may result in a high proportion of resistant progeny in these crosses. The tetraploid progeny were, based on the reports that we received, more vigorous with better yield and type than the diploids. The tetraploid cultivars might be expected to give a higher proportion of good types in their progeny simply because they have had more selection that the 2x Tbr clones. Increased genetic diversity probably also contributed to the greater vigor. In most instances, the

TABLE 3.- Parentage of hybrid potato clones that have been distributed for field tests for resistance to P. solanacearum

Phureja (R) x Phureja (R)
Phureja (R) x 2x Tuberosum (S)
Phureja (R) x 4x Tuberosum (S)
Phu-Tbr (FR) x 4x Tuberosum (S)

S - Susceptible in greenhouse; R - Resistant in greenhouse
FR - Resistant in field

TABLE 4. - Selection for resistance to P. solanacearum and for yield in potato hybrids distributed in 1968

Cross	Total Clones	Clones selected No.	%
Phureja x 2x Tbr	974	12	1.2
Phureja x 4x Tbr	93	23	24.7
Phu-Tbr x 2x Tbr	723	4	0.6
Phu-Tbr x 4x Tbr	159	32	20.1

Selections in Brazil, Colombia, Costa Rica, Mauritius, and Nigeria.

cooperators tried to select the highest yielding clones that were resistant and the percentage of clones selected from each cross does not necessarily reflect the actual number of resistant plants. Many plants died or were lost for reasons other than susceptibility to bacterial wilt.

The fact that so many clones were selected initially was very encouraging to us. Prior to this, it was not known if the resistance that we detected in the greenhouse would stand up in the field. These results and those obtained on other clones since then indicate that the resistance from Phureja will be useful for breeding programs.

It did not take long to realize, however, that resistance to bacterial wilt was only part of what was needed. In most areas where P. solanacearum is a problem, late blight (Phytophthora infestans (Mont.) de Bary) is also very severe. For this reason, some of the better yielding clones that have resistance to bacterial wilt but are susceptible to blight were crossed with sources of resistance to late blight. The primary resistant parents used have been the late blight-resistant varieties produced in Mexico that are known to have very good general resistance. The progeny from these crosses were tested for reaction to late blight in the Toluca Valley of Mexico through the courtesy of Dr. J. S. Niederhauser. Some of these clones have also been tested by several cooperators for resistance to bacterial wilt. Reports so far are very promising. Workers in Colombia, Peru and Nigeria have reported finding bacterial wilt resistance in clones that also were resistant to late blight in Mexico. If further tests confirm these results, then it should be possible to screen much larger populations and to select in each country good yielding clones that combine resistance to both diseases.

Based on the results of field tests that we have received, it appears that resistance to bacterial wilt has been detected in almost every country where screening has been done. Not enough data are available yet to determine if a clone that is resistant in one country will be resistant in another. The genetic evidence obtained so far suggests that they will not. Although in most instances, the resistant clones that have been isolated are not immediately useful as potential varieties, a considerable amount of germ plasm that will be of potential value to national breeding programs has been developed and distributed.

There are limits to the selection program that can be carried out in Wisconsin. It would appear that the future work at Wisconsin should stress certain basic problems, such as the nature and inheritance of resistance, and the development of new testing techniques. In our view, the primary responsibility for exploiting this germ plasm rests with the national programs. No barriers to the transfer of resistance have been detected so far and the chances for more progress in the future seem very good.

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PROGRESS AND PROBLEMS IN SELECTING RESISTANCE TO BACTERIAL WILT

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Drs. Rowe and Sequeira at Wisconsin have worked on selecting resistance to bacterial wilt (Pseudomonas solanacearum), in nearly constant temperatures and by means of stem inoculation. Their results have been good, but certain inconsistencies in field trials at different locations and from season to season, indicate the need to determine the interaction of: 1) day and night temperatures, 2) pathotypes, and 3) inoculation in soil or stem.

Day/night temperature regimes of the cold Andean (20/8°C) and of the coast (28/16°C) of Peru were simulated in phytotron chambers. The twelve hour long warmer periods included 9 hours of 500 Hlx. illumination with fluorescent "Cool White" and incandescent lights (in a proportion of 70: 30 watts respectively). The following potato cultivars were utilized: S. phureja 1386.15, 1386.26 (Colombian Collection), Wisconsin hybrids V-7, 7-6, 6-5, BR-6014 (derived from S. phureja), the North Carolina hybrid 59.B5-1, and "Russet Burbank". All these cultivars, with the exception of the last two have been selected as resistant or tolerant to bacterial wilt in Tropical America. Potato plants were planted in a Greenhouse and transferred 30 days later to the respective chamber. Three days later they were inoculated with suspensions of bacteria in water, prepared with wild-type colonies grown during 3 days at 30°C on Kelman's medium (without tetrazolium). Cultivars Russet Burbank (susceptible), 59.B5-1 (tolerant) and 6-5 (resistant) were inoculated by adding 40 ml of suspensions of the peruvian isolate P-1 of P. solanacearum to 500 cc of soil in each pot, with and without wounding the root system. Two concentrations of the bacteria were utilized: 1×10^8 and 4×10^8 cells/ml. Plants of all cultivars (3 per treatment, 2 replications) developed symptoms in 22 days in the warmer regime. In the cold regime Russet Burbank was susceptible in all treatments, 59.B5-1 was susceptible in all treatments except that it was tolerant at the low level of inoculum without wounding, while 6-5 developed symptoms only at the greater concentration of inoculum and when roots were wounded. Disease indices increased

with greater host susceptibility, greater inoculum concentration, presence of wounded roots, and increasing temperature.

Cultivars V-7, 7-6, BR-6014 and 1386.26 were inoculated (six plants per treatment, two replications) by puncturing the stem through a drop of bacterial suspension containing 2×10^{10} bacteria/ml placed on the axil of the third fully expanded leaf from the top or by adding 80 ml of a suspension of 5×10^{10} bacteria/ml to the soil of each plant in a 1500 cc pot. All plants were susceptible in 22 days when they were stem inoculated. In infested soil BR-6014 was susceptible in the warm regime, but tolerant in the cold regime, whereas the remaining cultivars were tolerant in the warm and resistant in the cold regime.

All cultivars were inoculated (3 plants in 2 replications) by soil infestation without root wounding with 80 ml of suspensions of 5×10^{9} bacteria/ml per 1500 cc pots with potato isolates P1 (Chiguirip, Peru), S 207 (Popayan, Colombia), S213 (Paraíso, Costa Rica), K51 (Pamlico, North Carolina), S245 (Antherton, Queensland, Australia), K197 (Kenya) and K56 (Israel). The results after 29 days are presented in Table 1.

Cultivars of *S. phureja* were the most resistant with cultivar 1386.15 being more consistently so than 1386.26. They exhibited only tolerance to some isolates, especially in the warm regime. No cultivar was resistant to all the isolates in the warm regime but only isolates P1 and S213 were virulent to all the cultivars (some showing tolerance, others susceptibility). In the cold regime for each bacterial isolate one or both *S. phureja* cultivars and one or more hybrids exhibited resistance, with the exception of isolate S213 to which the *S. phureja* cultivars were resistant but the hybrids tolerant or susceptible.

To summarize we can derive the following conclusions: the levels of resistance tested were well expressed by soil infestation without root wounding but not consistently so by stem inoculation. Resistance was greater in the cold regime and was more effective in certain cultivar-isolate combinations. These sources of resistance would seem to be adequate for some regions irrespective of temperature considerations, for other regions only in cold climates, and in still others they would only provide tolerance even in cold conditions. In the last of these instances they might be useful only if utilized with an integrated growing system that includes all possible control methods that might reduce the incidence of wilt.

TABLE 1.- Susceptibility* of potato cultivars inoculated by soil infestation with isolates of Pseudomonas solanacearum after incubation for 29 days at two temperature regimes.

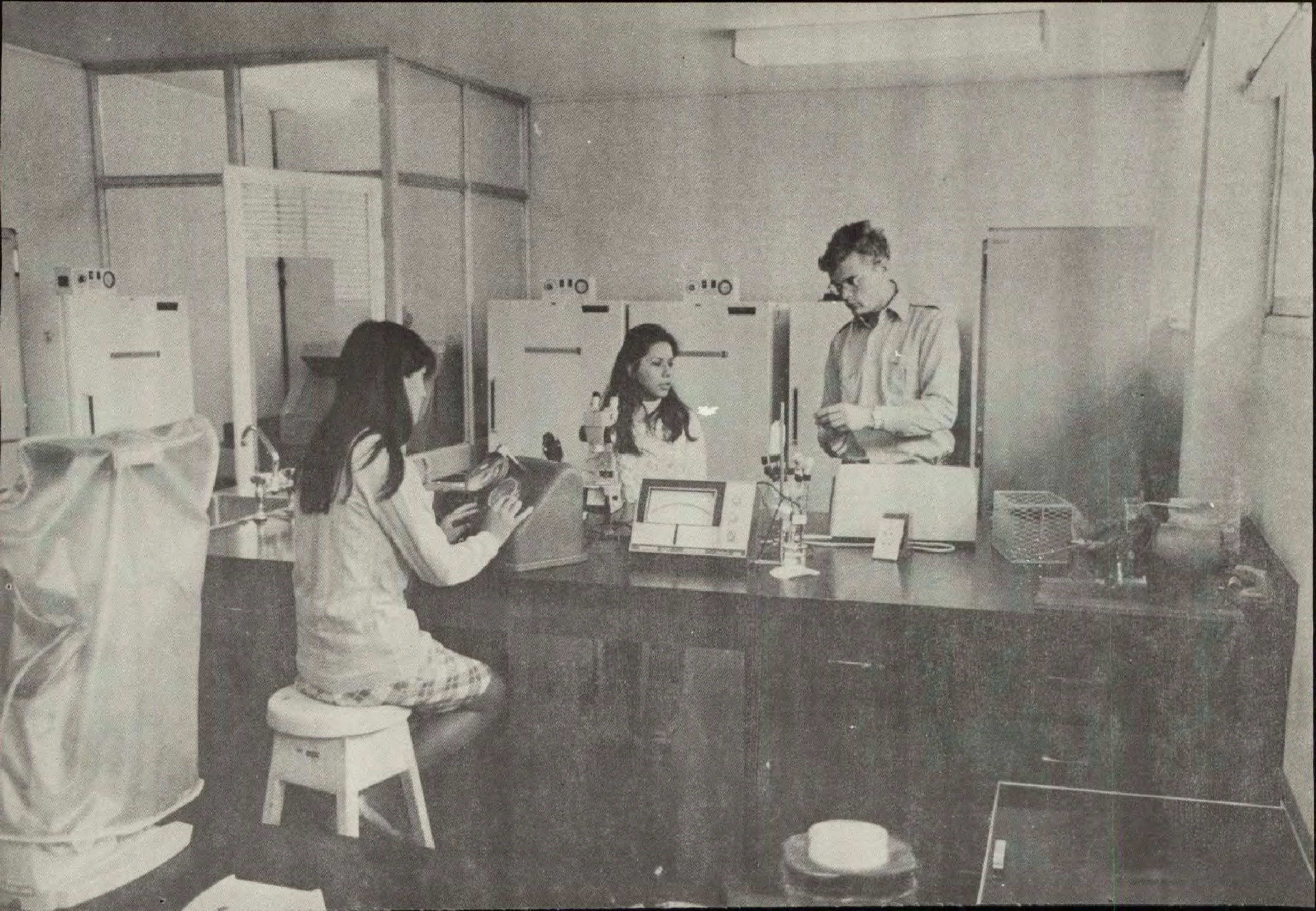
Isolates	Temp. °C	POTATO CULTIVARS					
		1386.15	1386.26	V-7	6-5	59.B5-1	BR-6014
P1	28/16	T	T	S	T	S	S
	20/8	T	R	T	R	R	S
S207	28/16	R	T	R	T	S	T
	20/8	R	R	R	R	R	R
S213	28/16	T	T	S	S	S	S
	20/8	R	R	T	T	T	S
K51	28/16	R	T	R	T	R	R
	20/8	R	R	R	R	R	R
S245	28/16	R	R	R	T	R	R
	20/8	R	R	R	R	R	R
K197	28/16	R	T	R	T	R	T
	20/8	R	R	R	R	R	R
K56	28/16	R	T	T	T	S	S
	20/8	R	R	R	R	S	T

* R = resistant; T = tolerant; S = susceptible.

EIGHTH SESSION

COLD RESISTANCE FOR THE HIGHLANDS TROPICS

Chairman, Vilhelm Umaerus
Principal Investigator, The Swedish
Seed Association



METHODS FOR EVALUATING POTATO FOLIAGE FROST RESISTANCE

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This presentation includes research contributed by several colleagues who have been evaluating potato foliage frost resistance at Minnesota (N.P. Sukumaran, C. Harrison) and in Bogotá (N. Estrada Ramos, L.F. Alvarado).

We have published an extensive review of the world literature on potato frost resistance from reported field observations, whole plant laboratory tests, and excised leaflet tests (3) and have grouped the reportedly resistant species into 5 levels of resistance. On the basis of published reports the most resistant species are S. acaule, S. chomatophilum, S. commersonii, S. x juzepczukii, and S. multidissectum, which are generally reported to be capable of resisting -5° C or lower without injury. S. acaule appears to be the most resistant with several reports of survival to -10°C. Slightly less resistant are S. ajanhuiri, S. x curtilobum, S. demissum, S. megistacrolobum, S. microdontum, and S. vernei which are generally found to be resistant in the -4 to -5°C range. Many other species of lesser resistance are also reported.

Dr. N.P. Sukumaran has developed a relatively simple, reproducible excised leaflet test for evaluating potato frost resistance involving controlled freezing of the excised leaflets and measurement of leached electrolytes (5).

In developing the procedure he tested plants of seven different genotypes including two cultivars and four Solanum species which had been asexually propagated from stem cuttings from single plants and grown under controlled conditions consisting of a 12 hour photoperiod and a 12°/2°C day/night temp regime. These genotypes tested ranged in frost resistance from a tender cultivar S. tuberosum subsp. tuberosum cv. "Red Pontiac" to S. acaule. Also tested were "Alaska Frostless", a cultivar which is a hybrid of S. acaule and S. tuberosum, which has been reported to have some frost resistance (1); S. chomatophilum and S. multidissectum which are highly resistant

species, and S. bukasovii which has been reported to be moderately resistant.

The excised leaflet test was performed as follows: A Wilkens-Anderson Lo-Temp bath (Model 94370) filled with ethylene glycol was used for subjecting excised, entire terminal leaflets to controlled temperature monitored by copper/constantan thermocouples and a Barber-Coleman multipoint potentiometric recorder. Whole leaves were washed in double-distilled deionized water and blotted with tissue paper, a terminal leaflet detached and placed in the bottom of each sample tube (15 cm test tube with a 1-holed rubber stopper inserted with a short glass tube). The sample tubes were weighted to float vertically and were almost completely immersed in the antifreeze bath. The temperature of the bath was rapidly lowered to -2° C, and maintained for 30 min. Temperature fluctuations were less than 0.2°C from the mean. Sample freezing was then initiated in each sample tube by rubbing a frost covered pipe cleaner up and down in the access tube of the stoppered cell. Then the bath was held at -2°C for 1 hour, then lowered 1°C/hour by manual adjustment every 10 min. Six leaflets of each genotype (2 from each maturing stage - young, intermediate and old leaves) were removed at each test temperature (0.5°C increments between -2°C and 6.5°C) and slowly warmed to 0°C in a refrigerator.

After 1 hour at 0°C, leaflets were gently removed from the cells and immersed in 50 ml of double distilled deionized water. All leaves of one genotype removed at a specific test temperature were placed in the same flask, transferred to a shaker bath and shaken at 29°C for 1 hour.

The liquid (leachate) was then decanted into a vial and the conductance measured at 60 cycles with an Industrial Instruments Conductivity Bridge (Model RC 16B2). The flask containing the leaflets was then dipped in liquid nitrogen for 5 min. to kill and disrupt all of the tissue cells. The original leachate was then poured back into the flask and samples were shaken again for 1 hour at 29°C. The leachate was again decanted from the disrupted leaflets and the conductivity again measured.

Percent leaching was then expressed as: Conductance of leachate after test freeze x 100% divided by conductance of leachate after killing all cells by liquid nitrogen.

Results of the studies indicate that the 50% leaching temperature for "Red Pontiac" and S. bukasovii was about -2.4 to -2.5°C compared with field reports surviving -2° to -3°; "Alaska Frostless" had a 50% leaching temperature -3.5° with field reports indicating that it survived to -3°; but was

killed at -5.5°C: S. multidissectum had 50% leaching at -4.5° compared to field reports indicating that it survived -3°on several occasions. The two genotypes of S. chomatophilum had a 50% leaching temperature of -5.5°C compared to field reports of survival at -3 to 5°C. S. acaule also had a 50% leaching temperature of -5.5°and has frequently been reported to survive -5° to -6°C or lower in the field.

For purposes of comparison whole, potted plants of the seven genotypes were also subjected to controlled freezing at a rate of 1°C per hour in a top-loading domestic freezer. During this procedure plants were inoculated with ice at -2°C to avoid extensive supercooling by gently rubbing a frost-covered pipe cleaner on the surface of a few leaves. The minimum test temperatures were maintained for 15 minutes. Plants were then thawed at 5°C/hour. Pots were insulated so that the soil remained unfrozen even to -6.5°C, the lowest test temperature used.

The foliage of whole plants of all genotypes was killed at the temperatures which caused 50% leaching from leaves of the same genotypes in the excised leaflet test. Stems generally survived these temperatures and in the case of "Red Pontiac", "Alaska Frostless" and S. acaule there was some new growth from axillary buds. Plants frozen to 1°C above the temperature causing 50% leaching in the excised leaflet test had either no visible injury or only marginal injury of a few leaflets (eg. on "Red Pontiac", "Alaska Frostless" and S. multidissectum).

The excised leaflet test appears to provide a reliable means of assessing frost resistance of potato foliage. Subsequent work has shown the results of the test to be highly reproducible and the temperature of 50% leaching provides a convenient means of reporting relative hardiness. While the test is relatively simple to perform it does require some specialized equipment and it is quite time consuming. As such it is not the simple mass selection tool which is needed to optimize effective frost resistance breeding programs. It does, however, provide a good standard for estimating the validity of simpler tests which may be developed, and in the meantime it provides a useful means for determining the relative frost resistance of numbers of genotypes - eg. advanced selections and potential parents.

Dr. Sukumaran has also attempted to characterize the nature of freezing injury to potato foliage (4). He found that freezing curves (time-temperature profiles) of freezing leaves from frost resistant (S. acaule) and frost susceptible (S. tuberosum cv. "Red Pontiac") types of potato leaves did not reveal any major differences. The pattern of change in electrical resistance of leaves to low voltage low frequency current during freezing was

different in the frost resistant and susceptible leaves. Using tissue sections from both types of leaves, he found that water freezes extracellularly when cooling is slower than 5°C/min. Cells from resistant plants showed a higher osmotic concentration, but not a higher water permeability than cells from susceptible plants. The extent of injury caused by even very slow freezing was greater than that caused by equivalent desiccation, particularly in the susceptible leaves. The higher osmotic concentration in cells from leaves of resistant plants can account for the greater desiccation resistance, but not for the frost resistance observed.

In summary, the results indicate that the frost resistance exhibited by S. acaule is true frost tolerance, i.e. ability to withstand extracellular ice formation to -5°C; that this resistance is not related to a relatively greater capacity for avoiding intracellular freezing during rapid cooling; and that injury to potato foliage from extracellular freezing probably cannot be explained in terms of simple frost desiccation.

Working with Nelson Estrada Ramos, frost resistance of interspecific and varietal potato crosses were evaluated in Bogotá using intact potted plants in programmed low temperature growth cabinets (2). Plants of 121 clones from 29 crosses were grown from tubers in a greenhouse with a 12 hour photoperiod and average day/night temperature of 25°/15°C. When the plants attained about 15 cm height, they were conditioned outside for 2 to 5 weeks. The average day/night temperature during this period was 19°/6°. After a minimum of two weeks of outdoor conditioning, groups of plants were transferred to Sherer-Gillett CEL-34-7 LT growth cabinets and subjected to frosts. Plastic temperature programming discs were cut to achieve a constant 20°C from 7 a.m. to 6 p.m. followed by a smooth lowering of temperature to a uniform 2 hour frost temperature between 4 a.m. and 6 a.m. The first frost temperature was -2°C followed by frosts of -3, -4, -5, -6, -7, -8, and -9 on subsequent nights. In all cases the relative humidity was 100% during the frost period. Foliar damage was visually scored 10-12 hours after each frost. Ratings were based on the following scale: 0 = no damage, 1 = less than 10% of the foliage damaged, 2 = 10 to 25% foliar injury, 3 = 25 to 50% injury, 4 = 50 to 75% and 5 = 75 to 100% foliar injury. Plants scored 4 or 5 were considered sufficiently damaged to consider them productively inefficient.

Results of the growth chamber tests of whole plant resistance to frost indicate that 101 of the 121 clones bred specifically for frost resistance survived without observable damage to at least -5°C and some crosses resisted -9°C. In the majority of cases the sources of resistance were well recognized resistant species such as S. acaule, S. brevicaule, S. multidissectum, and

S. vernei. However, some very resistant clones (like 65-3-4 d) were derived exclusively from cultivated species (G. Phureja or G. Phureja x Andigena) which hadn't previously been shown to be frost resistant. This is encouraging since it suggests that recessive, complementary or epistatic genes may be involved in frost resistance and it may be possible to obtain cultivated varieties with a fair degree of frost resistance by using varietal parents of cultivated species such as G. Andigena, G. Phureja, G. Stenotomum, S. ajanhuiri and others.

Most of these same clones have since been planted at several locations in Colombia and have been exposed to natural frosts at several locations, one frost was 5.8°C. The field evaluations by Luis Felipe Alvarado, Chris Harrison and others agree well with the data derived from this study using intact potted plants in programmed low temperature growth cabinets.

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SELECCION DE VARIEDADES RESISTENTES A HELADAS

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El 90% de la superficie cultivada con papa (90,000 hectáreas) en Colombia, está en peligro de que en determinadas épocas del año la temperatura baje hasta producir heladas en los cultivos y por consiguiente la pérdida total de la inversión. Por lo general, en los meses de Julio y Agosto se presentan estas temperaturas bajas que ponen en peligro los cultivos del primer semestre del año y las heladas de Diciembre y Enero son catastróficas para las siembras tardías del segundo semestre. De lo expuesto anteriormente, se deduce que este problema es bastante serio y que disminuye grandemente las inversiones de capital ante este peligro inmenso que de la noche a la mañana puede acabar con una buena producción.

El Instituto Colombiano Agropecuario consciente de este grave problema ha tratado de buscar soluciones, utilizando en el material híbrido, sangre de las especies silvestres que poseen alta resistencia o tolerancia a las bajas temperaturas con resultados a la fecha halagadores ya que se logró obtener la variedad ICA-Nevada que más adelante se describirá. No es que con esto se haya logrado una solución definitiva, sino que es un pequeño paso a la solución de tan grave problema. El Programa de Tuberosas del ICA continúa y continuará sus estudios y para ello se ha logrado una gran colaboración y ayuda del Departamento de Horticultura de la Universidad de Minnesota.

Varios estudiantes a nivel de post-grado han llegado a Colombia a realizar trabajos de tesis sobre este tópico. En esta Universidad se está trabajando (en lo que a este tema se refiere) especialmente en análisis de proteínas y métodos de laboratorio para evaluar resistencia del material producido en Sturgeon Bay en Wisconsin y en el Centro Nacional de Investigaciones Agropecuarias de Tibaitatá.

Uno de los primeros métodos que se ensayaron en Colombia para evaluar plantas resistentes a heladas, fue el de las curvas de congelamiento, por N. Sukumaran. Consistió en congelar hojas individuales y medir la curva de congelamiento con un potenciómetro de precisión. Específicamente se halló la diferencia del "plató" (plateau) que se forma al haber desprendimiento de energía durante el congelamiento. El encontró diferencias en el "plató" formado con variedades resistentes como _S. acaule_ y variedades sensibles de _S. tuberosum_, lo cual guarda relación con una mayor o menor resistencia a las bajas temperaturas.

Daryl Richardson y Nelson Estrada en un primer trabajo seleccionaron material valiéndose del método de cámaras de crecimiento. Estas cámaras están equipadas con programadores de temperatura y así se logra imitar las condiciones de bajas temperaturas más o menos como se presentan en el campo. Este método se empleó para plantas adultas individuales y por este sistema se probaron 121 clones en cámaras de crecimiento, seleccionaron como tolerantes 101 clones que resistieron hasta -5°C, también encontraron clones que resistieron hasta -9°C.

Entre el material usado en estos ensayos se encuentra el híbrido 60-177-7 cruce entre _S. andigenum_ variedad mambera por _S. stenotomum_ x _S. stenotomum_. Este híbrido se autofecundó para buscar si había un caracter recesivo ligado a esta resistencia y se ha logrado obtener varios clones resistentes, los cuales actualmente se están estudiando para determinar principalmente la cantidad de proteínas por el sistema de electroforesis.

Otro material con alta resistencia a bajas temperaturas son los híbridos 68 - 24 cruce de _S. acaule_ x _S. stoloniferum_ (CCC. 1120.1) y 68-32 cruce entre _S. brevicaule_ x _S. phureja_ (CCC. 81 yema de huevo).

El Programa de Tuberosas del ICA está ensayando un nuevo método para seleccionar material resistente a heladas. Es una combinación del método de cámaras de crecimiento y observación directa en el campo. Alvarado L.F. realiza estos estudios. El método se inició con material en la primera generación cuando las plántulas tienen unos 15 centímetros de altura, se someten a temperaturas de -3°C en cámaras de crecimiento por 2 horas imitando una helada natural en condiciones de Colombia. El material que sobrevive se trasplanta al campo por encima de los 3,000 m.s.n.m. en donde se prueba en condiciones de heladas naturales.

Siguiendo este método se ha logrado observar que las heladas naturales, eliminan más material que el método del laboratorio, pero que si guar-

da una relación bastante aproximada entre lo seleccionado por las cámaras y lo descartado por heladas naturales. Del material probado, el que más se ha destacado por su resistencia a bajas temperaturas están los cruzamientos siguientes: S. brevicaule x S. phureja (Solimán); S. brevicaule x S. phureja (Yema de huevo); S. brevicaule x S. phureja (CCC. 1548); ICA-Nevada x S. andigena (Tuquerreña); ICA-Nevada x S. andigena (Parda Pastusa); S. vernei x S. phureja (Reina); S. ajanhuiri x S. phureja (Yema de huevo); y, S. ajanhuiri x S. phureja (CCC. 1360).

Como se puede observar, para los cruzamientos se han utilizado variedades silvestres y cultivadas que se han reconocido por su tolerancia a bajas temperaturas. Los híbridos seleccionados como resistentes a heladas, son cruzados luego con variedades comerciales que poseen buenas características agronómicas, con miras a obtener variedades con alto contenido de proteínas y buena aceptación comercial. Con este método, se logrará ahorrar mucho trabajo y se podrá trabajar con poblaciones grandes, desde la primera generación.

Por último, merece anotar la variedad ICA-Nevada, cruce entre dos variedades de S. phureja, que ya se tenía en Pruebas Regionales y en estudios de adaptación con Agricultores por buena resistencia a Phytophthora infestans y excelentes cualidades del tubérculo: color rojo intenso combinado con crema, los cuales gustan mucho en Colombia, carne crema, buena calidad y buena forma. En las pruebas regionales hechas en 1971, el promedio de producción por hectárea fue de 32.7 toneladas, siendo la variedad más productiva de las 20 que se ensayaron y en donde la variedad testigo, la más difundida actualmente entre los agricultores de nombre Parda Pastusa fue de 16.3 toneladas por hectárea.

En Julio de 1969, se la sometió a la influencia de temperaturas bajas en cámaras de crecimiento, con un 10% de quemazón del follaje después de soportar una temperatura de -4°C por dos horas y humedad relativa de un 100%. También se ha podido observar el comportamiento de esta variedad en heladas naturales (-5°C) en donde ha confirmado esta característica de resistencia a temperaturas bajas.

NINTH SESSION

VIRUS RESISTANCE FOR TROPICAL AREAS

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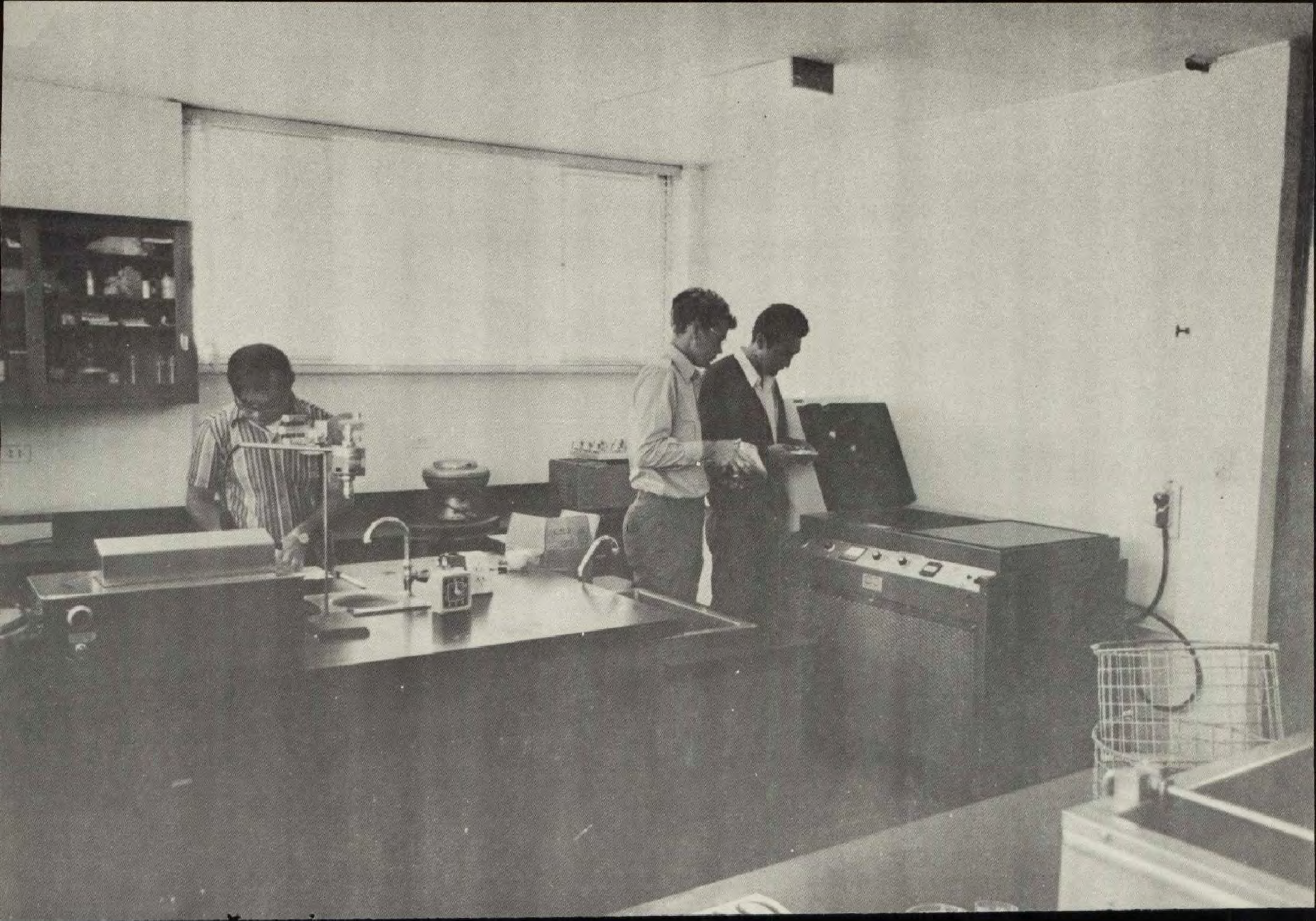

RESISTENCIA Y TOLERANCIA A VIRUS

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Las enfermedades virosas de la papa es uno de los factores principales que limitan su producción en el mundo. El fenómeno llamado "Degeneración" de las variedades se conoce que es causado por las enfermedades virosas y no directamente por las condiciones ecológicas o por la edad de la variedad.

Como método de control la selección de variedades resistentes a los virus más prevalentes y dañinos ha merecido la atención de muchas instituciones dedicadas al mejoramiento de la papa en todo el mundo. De esta manera, se conocen algunos éxitos en la obtención de resistencia extrema para algunos virus que causan mosaicos, como virus X (PVX), virus Y (PVY) y virus A (PVA), más no para Leaf-roll al cual solamente ha podido hallarse resistencia a la infección y tolerancia.

La resistencia a los virus ha sido expresada en varios tipos de reacciones:

- Inmunidad o resistencia extrema
- Hipersensibilidad
- Resistencia a la infección
- Resistencia a la alimentación del vector, y
- Tolerancia.

La inmunidad es el tipo de reacción más preferida; sin embargo, se sabe que no es fácil de lograr; por esta razón cualquiera otra expresión de resistencia es buena tomándose a la tolerancia sólo en último caso ya que existe la probabilidad de que cualquier forma de control genético pueda ser eliminado por alguna mutación en el virus. Considerando la variabilidad de los virus se comprende la necesidad de conducir estudios sobre resistencia en forma continua. Un ejemplo que confirma lo anteriormente dicho es lo que ocurre con el clon de papa U.S.D.A. 41956. Este clon ha sido indicado como in-

mune a PVX en otros lugares; sin embargo, inoculaciones previas con una raza peruana del virus han demostrado que el clon es susceptible. A pesar de que estos resultados son preliminares indican que la pérdida de algun tipo de resistencia puede suceder con otros virus, especialmente fuera de lugar donde ésta ha sido determinada.

Los trabajos sobre búsqueda de fuentes de resistencia para los virus en el germoplasma del CIP han sido planeados después de analizar los siguientes criterios:

a) Magnitud del daño que causa el virus
b) Conocimiento actual del virus
c) Conocimiento del material a evaluar.

En forma general, se considera que la magnitud del daño que causa un virus depende del huésped y de los factores que favorezcan su diseminación, mientras que el conocimiento del virus en cuanto a su forma de transmisión y otras propiedades además del huésped permitirán determinar la tecnología más apropiada para el estudio. Se ha considerado de máxima importancia el conocimiento de la variabilidad del virus para el cual se busca resistencia.

Muy poco puede adelantarse sobre los trabajos que se han iniciado por razones obvias; sin embargo, entre 1,000 clones que se han evaluado para detectar la presencia de PVX se han hallado 350 clones libres del virus y algunos que a pesar de estar infectados no muestran síntomas. Teniendo en cuenta que la mayor parte de estos clones han sido mantenidos por más de 15 años en condiciones de campo, las posibilidades de infección con PVX y otros virus han sido grandes, por lo que los clones libres pueden tener algun tipo de resistencia la cual es conveniente determinar.

La metodología que se está siguiendo en los estudios de PVX ha sido planeada de acuerdo a la forma actual de propagación del material y de su estado sanitario. De esta manera se puede resumir lo siguiente:

a) Determinación de infección con el virus por inoculación mecánica sobre <u>Gomphrena globosa</u>.

b) Inoculación con dos razas del virus a los clones que demuestren estar libres bajo condiciones de invernadero.

c) Experimentos de campo. Exposición del material a infección natural.

Los dos primeros puntos permitirán la determinación de susceptibilidad, hipersensibilidad e inmunidad, mientras que el último además de comprobar las reacciones anteriores permitirán determinar la resistencia a la infección y tolerancia. Es evidente que puede incurrirse en algún error al hacer los estudios con material que pueda estar infectado con otros virus; sin embargo, el riesgo es mínimo ya que su presencia será determinada, en lo posible, en todos los clones que indiquen algun tipo de reacción de resistencia.

Los estudios sobre resistencia a otros virus seguirán esencialmente la misma secuencia que para el virus X. La excepción estará dada por la forma de transmisión natural del virus y las técnicas tendrán que ser adecuadas a las circunstancias.

NEWLY DETECTED POTATO VIRUSES IN PERU

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Potato Virus Y (PVY) and Potato Virus X (PVX), the most common potato viruses affecting potato in other areas of the world have been found under Peruvian conditions. The former induces vein necrosis on Renacimiento variety, the latter seems to be present as several closely related strains inducing mainly mosaics. The symptomatology of PVX on indicator hosts is the same as reported for the common strain but the dilution end point is unusual as it is above 1/1,000,000. The thermal inactivation point is variable between 65-70°C and 70-75°C.

From potato plants showing different symptoms we have isolated 3 viruses which were named: 1) Calico, 2) Mosaic - 1 and 3) Mosaic -2 . Calico was isolated from plants of the variety Ticahuasi in the central coast region, and mosaic-1 from Renacimiento plants showing mosaic, and mosaic-2 from an unknown variety in Huancayo valley with symptoms of strong mosaic, cupping of the leaves and some necrosis. The symptoms of these 3 viruses on indicator plants are given in Table 1.

Calico had a wide host range and it induced necrotic-ring spot symptoms. The other two viruses induced mainly mosaics. From a large number of indicators tested, N. occidentalis and N. megalosiphon were the most useful as they reacted with the three viruses.

Attempts to transmit calico with Myzus persicae gave negative results. Later we found a similitude between this virus and a virus isolated from tobacco which we believe is tomato spotted wilt (TSWV). However, calico failed to protect tobacco from entre of TSWV and when tested against TSWV antiserum, results were negative. In subsequent inmuno difussion tests this virus reacted against tobacco ring spot antiserum.

TABLE 1. Symptoms induced by three viruses isolated from potato, on indicator hosts.

	Calico	Mosaic 1	Mosaic 2
Datura stramonium	mosaic, necrotic	no symptoms	no symptoms
Chenopodium quinoa	necrotic sunken spots	no symptoms	no symptoms
Gomphrena globosa	epinasty, mosaic	no symptoms	mild mosaic
Nicotiana debneyi	chlorotic-necrotic rings	vein clearing	no symptoms
Nicotiana occidentalis	chlorotic-necrotic rings	strong mosaic	mild mosaic
Nicotiana megalosiphon	chlorotic-necrotic rings	mosaic	mosaic, necrotic spots
Solanum chancayense	leaf necrosis	mosaic, leaf deformation	no symptoms
Solanum chacoense	no symptoms	mosaic	no symptoms
Solanum demissum	no symptoms	necrotic spots	mild mosaic

TABLE 2. Symptoms induced by three viruses isolated from potato on indicator hosts; and their physical properties

	Virus 3	Virus 4	Virus 5
Gomphrena globosa	necrotic spots	no symptoms	no symptoms
Chenopodium quinoa	chlorotic spots	no symptoms	no symptoms
Nicotiana glutinosa	necrotic spots	no symptoms	no symptoms
Nicotiana rustica	no symptoms	chlorotic spots	no symptoms
Nicandra physaloides	necrotic spots	no symptoms	no symptoms
Phaseolus vulgaris	necrotic spots	vein necrosis	no symptoms
Dilution end point	$10^{-4}-10^{-5}$	$\pm 10^{-3}$	-
Inactivation point	70-80°C	± 60°C	-
Resistance to aging	months	days	-

On the basis of symptomatology mosaic-1 appeared to be PVY but when inoculated to the clone A6X it did not induce the formation of typical necrotic spots; neither did it react with PVY antiserum. In cross protection tests using Physalis floridana as an indicator host it failed to protect this plant from entry of PVY; on the contrary, there appeared to be a synergistic effect. Transmission by Myzus persicae could not be demonstrated.

Mosaic - 2 infected several species which reacted with mild mosaic or no symptoms. We could not find a similitude between this virus and any known potato virus.

The identity of these viruses, with the exception of calico, remains obscure. Physical property and electron microscopy studies will help complete the identification process.

Three other viruses have been under study for identification. These, named virus-3, virus-4 and virus-5 have been isolated from potato plants showing symptoms of fine necrotic dots, necrosis of leaf margins and apical leaf roll respectively.

The symptomatology of these 3 virus on some indicator hosts, and physical properties, are given in Table 2.

Both virus-3 and virus-4 could be transmitted mechanically. Virus-5 was transmitted only by grafting and by aphids (it is apparently a circulative virus with an acquisition feeding periods of 3 days).

Physical properties of the first two viruses were determined. Virus-3 seems to be rather stable, with a high thermal inactivation point and great resistance to aging.

No similitude could be found between these and other known potato viruses. Further studies will determine if they are new viruses.

TENTH SESSION

ADAPTATION OF THE POTATO TO THE LOWLAND TROPICS

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MAJOR PATHOLOGICAL RESISTANCES NEEDED FOR ADAPTING THE POTATO TO THE LOWLAND TROPICS AND THE POSSIBILITIES OF OBTAINING THEM

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This paper is not a comprehensive survey of the literature on major pathological resistances needed for adapting the potato to the lowland tropics, since there was insufficient time to undertake a thorough review due to the short notice with which this symposium was organized. Much information is lacking to do more than draw attention to what appear to be the major factors. It becomes evident in looking at the literature, however, that considerable gaps in our knowledge of problems exist, and that a cooperative effort to define problems - present and future - would be useful.

One major problem in evaluating published information is that authors seldom give the altitude at which a problem was found or work was conducted. Another problem is to define lowland tropics. The tropics consist of the zone bounded on the north by the tropic of Cancer and on the south by the tropic of Capricorn. The latitude at these points is 23°27'. Some would extend the tropics to include the area between 30° North and 30° South latitude. A few minutes of study with a globe will show that most "developing" countries are in or on the border of the tropics. Uruguay, for example, is the only country of Latin America with its boundaries entirely within the temperate zone. In Africa only Morocco and Tunisia are entirely within the temperate zone.

Because of the effect of altitude, many crops grown in temperate zones are also grown in the tropics. Seasonality exists with respect to rainfall, but the extremes and seasonality of temperature we experience in temperate zones does not. Daylength also has a striking effect on crops (including potatoes) in the tropics, but changes in length of day and in solar radiation are small in comparison with the corresponding changes in temperate zones. Thus, even when working with crop plants which are common in temperate zones,

adaptive research is necessary when working with them in the tropics. The tropics should not be thought of as a single unit however, as a wide diversity of ecological and climatic regions can be found within them.

There are other ways of defining the tropics than by latitude. To quote Wellman (33) "The thermal equator, also called the heat equator, as it occurs in the Western Hemisphere slants downward from north to south, not following the geographical Equator and only touching it once, where they cross. Its north and south edges are limited to where there is year round growth of freezing-sensitive plants such as palms".

We still haven't defined "lowland tropics", but perhaps some of the complications involved in defining it are more apparent. We will arbitrarily here define lowland tropics as those regions of the tropics at elevations between sea level and 1000 meters. Although these areas range from very wet to very dry, they represent the greatest remaining potential for producing food for an exploding world population. Almost 90% of Latin America is lowland, yet only a small percentage of its population lives in the "lowland tropics".

First let us look at areas where potatoes are grown in "lowland tropics". Table 1 gives the production and area of potatoes in some "tropical countries". Accurate data do not exist with which to give the percentage of potatoes in each country that are grown below 1000 m, but at the risk of getting into trouble we will engage in some speculation.

In Colombia the lowest elevation at which potatoes are extensively grown commercially is 1760 m. Potatoes can and have been grown at 1000 m (i.e. Cali), but because extensive highland areas are available, it is not economic in Colombia to grow potatoes at lower elevations.

Potatoes are grown in Ceylon from 750-2000 m (32). Venezuela has some potato production in the Andes at high elevations, but much of the potato production is at 400-600 m. According to Montaldo (20) about 50% of the potato production in the states of Aragua and Carabobo of Venezuela was between 450-1000 m.

Almost all of the potato production in Brazil is below 1000 m in the states extending from Rio Grande do Sul to Minas Gerais at latitudes from 25° to 30° according to Deslandes (7).

TABLE 1. Hectares grown and production of potatoes in selected tropical countries. 1/

Country	Area – Hectares	Production – Metric tons
Brazil	240,000	1,690,000
Ceylon	3,000	24,000
Colombia	100,000	1,110,000
Congo	3,000	16,000
Costa Rica	2,000	17,000
Cuba	9,000	120,000
Ecuador	47,000	370,000
Jamaica	2,000	13,000
Kenya	55,000	200,000
Panama	2,000	9,000
Philippines	3,000	18,000
Venezuela	16,000	136,000
Africa	319,000	2,234,000
Latin America	1,144,000	9,709,000

1/ Data from 1970 FAO World Production Yearbook. Vol. 24.

In Peru, although the Pacific coastal area is a specialized case since it is cooled by the Humboldt Current and receives almost no rainfall, extensive potato production under irrigation is found near sea level.

The two major disease problems of potatoes in the "lowland tropics" which are obvious are bacterial wilt caused by Pseudomonas solanacearum, and viruses. However, many other disease problems are found in the lowland tropics and we will try to identify the more important ones.

P. solanacearum is widely distributed in almost all tropical areas (1,6,14) and attacks a wide range of wild and cultivated crops including potatoes, tobacco, bananas, tomato, eggplant, and peanuts. There are three races (6) but only two of them (races 1 and 3) are economically serious on potato. Race 2 (the banana race) will however, affect potatoes when artificially inoculated (29). Race 3 from potatoes has a lower temperature optimum than the other races (21, 28) which permits disease development at higher elevations with cooler temperatures (13,28). However, this lower temperature optimum does not appear to result in a reduced virulence at high temperatures

with respect to race 1 isolates (8). It is probable that race 1 is of greatest importance in the lowland tropics. It is well established in the literature that race 1 of P. solanacearum is an organism that causes disease only under relative high temperatures. Most authors give 30-35°C as the optimum in vitro for P. solanacearum. In the field Meier & Link (19) on the basis of observations, not experimental data, list 25-36°C as optimum for disease development in potatoes and state that below 13°C the disease is inhibited. Vaughn (31) working with tomatoes in the greenhouse found that infections occurred at a soil temperature of 12.8°C but that ordinarily symptoms did not develop unless the soil temperature remained at 21.1°C or higher for several days; at soil temperatures of 21.1 - 43.3°C the rate of disease development increased as temperature increased. Gallegly & Walker (10), also working with tomatoes in the greenhouse found that the disease developed most rapidly in plants grown in soil at 30-36°C. When the soil temperature was maintained at 28°C and plants were grown at different air temperatures, maximum disease development occurred at an air temperature of 28°C.

From the above data it can be concluded that race 1 of P. solanacearum can attack potatoes at most of the soil and air temperatures that would be found in the lowland tropics.

Several authors state that P. solanacearum is a limiting factor in growing potatoes at low elevations in the tropics and that the disease becomes more important as temperatures increase, i.e. potatoes are grown at lower elevations (3, 14, 28, 32, 34).

Much of the literature (14) indicates that the bacterium can survive in soil for long periods of time without susceptible hosts. However, Sequeira (25) found that following, and planting Kudzu for 24 months effectively controlled race 2 of P. solanacearum in the soil. Even 18 months greatly reduced populations. He suggests that the bacteria may not survive in the soil for long periods without susceptible weed hosts. This control method may not be feasible in the lowland tropics because of the many plant hosts of P. solanacearum and the difficulties of maintaining a completely clean fallow for long periods of time. This method also may not be as effective against race 1 which attacks potatoes and other Solanaceous hosts. In Kenya Robinson (23) noted that the pathogen could survive for many years in infested soil and that once infested, land is essentially ruined for further potato cultivation.

Many control methods have been suggested for control of bacterial wilt in the lowland tropics (14), including chemical control; rotations, fallowing, flood fallowing, the use of certified seed, etc., but none of these are effective on an economic basis once the organism becomes established.

Resistant varieties seem to be the only practical solution to control of bacterial wilt of potatoes in the lowland tropics. Nielsen & Haynes (22) initiated a program in 1947 looking for resistance to P. solanacearum in potato and eliminated a large number of clones of Solanum tuberosum and other Solanum sp. as possible sources of resistance. Several other studies have been made to locate acceptable levels of resistance (14, 27, 32) but none of the clones selected for resistance survived when planted in several tropical areas.

Robinson (23) found both vertical and horizontal resistance in potatoes to P. solanacearum and recommends concentrating on horizontal resistance. Thurston (29) and Thurston & Lozano (30) found high levels of resistance to P. solanacearum in S. phureja, which was also found to be useful in Kenya by Robinson (23) and in Wisconsin by Sequeira & Rowe (26) and Rowe & Sequeira (24). Some S. phureja clones were resistant to races 1, 2, and 3 and in addition to many isolates of different virulence (26, 30). Preliminary results in Colombia, Brazil and Costa Rica indicate that the S. phureja resistance holds up in the field (26). Rowe & Sequeira (24) found that three, dominant and independent genes provide resistance. Although S. phureja is a diploid it can readily be crossed with haploid S. tuberosum clones and Sequeira & Rowe have developed resistant cultivars with acceptable commercial characteristics plus resistance to Phytophthora infestans.

It is hoped that this resistance to P. solanacearum found in S. phureja will be useful in the lowland tropics, and potato workers are urged to test it under their field conditions.

Potato species are found in their regions of origin at elevations that range from close to the lowland humid tropics to close to the snow belt. The diseases affecting them are, like the potatoes themselves, adapted to a given range of environmental conditions. These ranges, however, vary considerably from one individual cultivar to another, be it host or pathogen that is under consideration.

There is considerable evidence for the adaptability of potato pathogens to new environments, but also for the adaptation of non-pathogens to potatoes when these are grown in new habitats. Examples of the first are quite apparent when one considers that potatoes are grown in regions very distant from their centers of origin and that most of the diseases known at these centers of origin, have travelled and prospered with them. Indications that some of these diseases are adaptable or more damaging when potato cultivars originating in the cool highland tropics are grown in warmer tropical locations, are found in observations of the incidence of some diseases of the highlands

of Peru, that are now known on the cool-to-warm irrigated and coastal valleys where potatoes have been grown for only a few decades (9), as follows:

1. Sclerotium rolfsii, the cause of basal rot or "Southern blight" is more serious the warmer and more humid the conditions.

2. Thecaphora solani, the causal agent of potato smut, is far more serious in the coastal valleys than the highlands, resulting in near total losses or the need for long rotations.

3. Phytophthora erythroseptica (which causes pink rot) is becoming increasingly serious in the coastal valleys, its incidence increasing with higher temperature and humidity.

4. Purple top or Aster yellows "virus" – this disease is rare in the highlands, but can cause total loss of productivity on the coast where the leaf hopper vectors and principal hosts are common. This principle applies to many viruses that are transmitted by numerous insects that proliferate under warm (and moist) conditions.

5. Meloidogyne incognita – the root knot nematode is important wherever introduced along the coast, but is most severe in the warmer locations on the fringe, or beyond the range of normal production.

6. Sclerotinia sclerotiorum – Sclerotinia disease, is common although not severe in the highlands, but has caused severe losses at some coastal locations.

7. Colletotrichum atramentarium – black-dot is not considered a virulent pathogen elsewhere, but on the coast of Peru it is quite damaging.

Evidence for the adaptation of a non-pathogen to cultivated potatoes has been hinted at by the sequence of events in the development of an epidemic of brown rot (Pseudomonas solanacearum) in Peru. The disease was first noted in an isolated area at a low elevation (2000 m) at a near-jungle location. Three years later it had apparently spread, through the indiscriminate use of tubers for seed, from that location to neighboring ones at varying elevations. The disease was less evident at higher altitudes to the point that at the hither sites (3,200 m) no sumptoms were evident, but when tubers from these plants were planted at lower elevations, they were shown to be carriers of the disease (9). The original source of the bacterium was probably a solanaceous plant, possibly even a wild potato.

From the above examples, it is evident that some diseases will accompany potatoes, if adequate means from their dispersal exist, from cool to warmer tropical locations. Evidence could also be presented for the likelihood that some diseases would not adapt to the warmer conditions. Other microorganisms may adapt and also become pathogens to potatoes. It therefore seems likely that the magnitude of the problem will depend upon the particulars of each lowland tropic location. It would, however, seem most likely that potatoes could be adapted most readily to growth in the atipical lowland tropical environment, i.e. locations where cultivation can be carried out in the drier season (with irrigation if necessary), abnormally cool locations like those of coastal arid Peru, island climates, etc.

Many of the common diseases of potatoes have been sporadically reported when potatoes were grown in the lowland tropics. Unfortunately it is difficult to judge from the literature how widespread or severe they are. Some of those mentioned as serious follow.

Several species of nematodes seem to cause serious losses on potatoes in the lowland tropics. Several species of Meloidogyne (root knot nematodes) including Meloidogyne incognita are frequently noted as damaging (2, 15, 16, 17, 18). The golden nematode (Heterodera rostochiensis) although present in the coastal region of Peru does not seem to multiply to high populations or cause the serious losses that it does in the higher elevations. Considerable work needs to be done to determine the importance and potential of nematodes in lowland potato plantings.

Black leg (Erwinia carotovora) was noted as a serious problem in trials in Trinidad (12). The organism (Erwinia carotovora) causing soft rot of potatoes is known to be more serious under conditions of high temperatures, thus storage problems in lowland tropical areas will be more difficult than in cool climates. Black wart (Synchytrium endobioticum) has occurred on potatoes in some lowland areas in Peru (11). Verticillium wilt caused by Verticillium albo-atrum is reported to be an important disease of potatoes in the coastal area of Peru (4).

Viruses will undoubtedly be one of the most serious problems of potatoes in the lowland tropics. The optimal conditions for insect vectors, high rainfall and consequent difficulty of insect control, will mean that new seed will have to be provided at more frequent intervals than in higher, cooler areas. Which viruses will be more serious is unknown.

It is not necessary to review the voluminous literature on Phytophthora infestans which causes late blight of potatoes, since it has already been

done many times. Little information was found on the importance of P. infestans in the lowland tropics. In the humid but near rainless central coast region of Peru where potatoes are a winter crop late blight can become a limiting factor to potato production during certain years, unless a spray schedule is implemented (5). Since the authors have also seen late blight on tomatoes in the lowland tropics, there is little doubt that it will be of importance on potatoes.

With the exception of the discussion on bacterial wilt caused by P. solanacearum little has been said on sources of resistance to the diseases of potatoes in the lowland tropics. It is beyond the scope of this paper to adequately discuss sources of resistance for potatoes to the multitude of diseases present in, or potential to the lowland tropics. Because of the often primitive nature of agriculture in many areas of the lowland tropics breeding for disease resistance may often be the only practical and economic method of disease control. Disease resistance will undoubtedly be found if past experience is any guide, but the task of assembling and screening the germplasm will be gigantic. Undoubtedly, much of the resistance may be found in Solanum species adapted to the lowland tropics, and such resistance may not be readily transferrable to clones suitable on the basis of their adaptation to the tropical lowlands. A negative factor to be taken into account is that when selection pressure is applied for agronomic or physiologic adaptation to the lowland tropics, there will be a tendency to "loose" some useful genes, including those for disease resistance. The Centro Internacional de la Papa can serve a most useful function in the overall problem of identifying disease problems in the tropical lowlands and finding resistance which will help control these problems.

The following are suggestions of activities which might be considered:

1. Compilation of a comprehensive literature review on pathological problems in the lowland tropics.

2. Establishment of long term "disease nurseries" or "disease gardens" in different representative lowland tropical locations to determine on a standard set of potato clones the problems now present and those which may develop.

3. Establishment of a newsletter for "lowland tropical potato workers" to facilitate communication among research and extension workers.

4. Support of project to locate resistance to the most serious disease problems of potatoes in the lowland tropics.

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METHODS FOR ADAPTING THE POTATO TO THE LOWLAND TROPICS

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To increase yield of the potato crop or to improve the quality of the tubers two ways can be followed: development of breeding programmes, and improvement of growing methods. These two ways are as applicable to the Lowland Tropics, as they have been shown to be elsewhere.

In this symposium much attention is being paid to the improvement of the potato crop by breeding. For the long run this is a very important way to increase yield and quality, especially for difficult conditions as those that occur in the Lowland Tropics. However, we must be well aware that to breed new varieties that can produce more than the existing ones requires considerable time. As it is so important to improve the crop in a short time, I would like to draw your attention to the second way, namely the improvement of growing methods.

To discuss the growing methods we could take the various methods separately, such as soil preparation, fertilization and irrigation. I would prefer to discuss with you some characteristics of the crop in relation to growing methods. These are the ratio haulm weight/tuber weight and tuber size and shape. I will discuss very briefly which factors influence these characteristics of the crop and how growers may use these factors to adapt the crop to specific conditions. I will also make some remarks on the introduction of new varieties, and seed supply. Though these two subjects do not belong to methods in a narrow sense, they are important to achieve results in a short time.

Introduction of the best adapted varieties

To be sure that the best available varieties are grown in a country or in a certain region, an extensive varietal testing programme must be carried

out. Even in a small country like the Netherlands in which in comparison with most countries an extremely small climatic variation exists and yearly only one planting time occurs, 30 varietal trials are carried out.

To limit the number of varieties that must be tested it appears to be advisable to test in a few places all varieties in the world that may be of interest in the region and to select from these after one or two years a reasonably small number to be tested in many places. Not only the number of varietal trials is important, but also the quality of the observation. It is very important to give afterwards explanations for the obtained differences in yield. Well executed varietal trials stimulate research to adapt the best growing method for promising varieties.

A specific point for the conditions of the lowland tropics is the reaction of varieties to fairly short days and high temperatures. It is evident that varieties whose haulms are damaged by high temperature or whose haulm growth is restricted by periods with high temperature, should be excluded. Good haulm growth at high temperature is not sufficient; as it is well-known that high temperature can disturb the balance between haulm and tubergrowth in the direction of haulmgrowth. By varying the growing methods, something can be done to bring haulm and tubergrowth into a proper balance.

Haulmweight/tuberweight ratio

The ratio haulmweight/tuberweight is an extremely important characteristic of a potato crop. I would like to call it the growth type of a crop. A crop with a long growing season should show another growth type than a crop with a short growing season. This is explained in Fig. 1. Several factors influence this growth type. Factors that stimulate haulmgrowth are: seed tubers and sprouts that are physiologically young, long days, low light intensity, high temperature, high nitrogen supply, high water supply of the soil and high stem number per m^2. Tuber growth is stimulated by the opposite of these factors. Also the variety affects this ratio. Some varieties form abundant haulms (in general late varieties in temperate zones), and others form less haulms (in general early varieties in temperate zones).

In Europe growers make use of the mentioned factors to influence the ratio haulmgrowth/tubergrowth. For early crops, such as those for seed potato production in Holland farmers try to plant seed that is physiologically fairly old, and apply much less nitrogen that on crops that can be harvested late. The seed for these crops - crops with a long growing season - should be physiologically young.

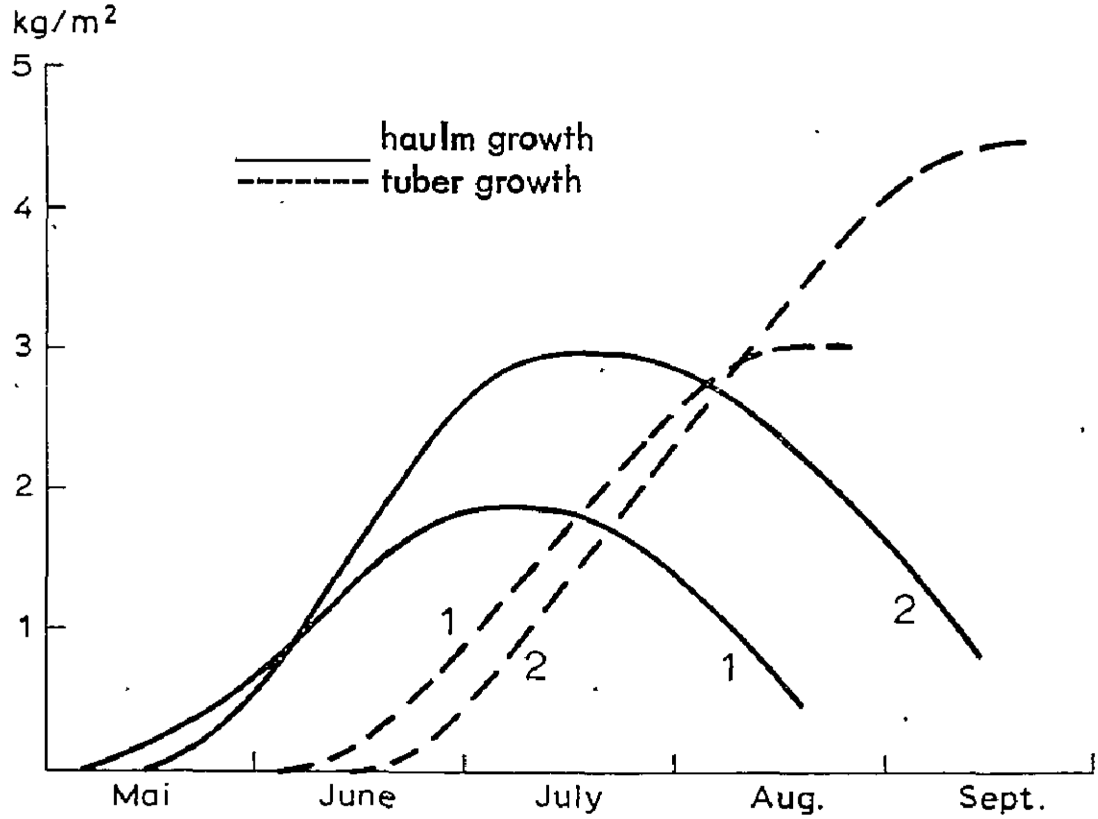

FIGURE 1. Two growth types: 1. crop from physiologically old seed
2. crop from physiologically young seed

Under lowland tropic conditions the temperature is such a predominant factor that the balance between haulmgrowth and tubergrowth is disturbed in the direction of haulmgrowth, with the result that tuber yield is often poor, despite the short days and the high light intensity. I therefore suggest that research should be done to obtain more information on the effect of physiological age of the seed tubers and sprouts, water and nitrogen supply and stem number on the growth type of the potato crop in lowland tropic conditions. Such information could then be applied to obtain a more optimal ratio under these conditions.

Tuber size and shape

Total tuber yield is not so important as the yield of tubers that can be marketed. To improve the yield of tubers of the desired size, it is essential to know the factors that influence this size. Next to tuber yield, the number of main stems is an over riding factor. This is shown under Dutch conditions in Figure 2. Figure 3 gives these and other very important factors. Research on these factors under tropical conditions is essential so that growers can make use of it.

For the market the regularity of the shape of the tuber is important. Irregularities such as growth cracks, swollen protrusions from the eyes and prolongation and swelling of the rose-end are the first signs of second growth. A crop grown under high temperature conditions can be extremely sensitive for second growth. Each growth shock must therefore be avoided, that means that an even water supply of the crop is essential. This can be achieved by regular irrigation and by intensive rooting of the sub-soil, so that the water in a deep layer of soil is available for the crop. This may help to overcome shortage of water during short periods. I believe that more information is needed for the tropics on the relationship between irrigation and rootgrowth on one side and tuber shape and yield on the other side. This information may help to improve the regularity of tuber growth. That means higher yield and less misshapen tubers.

Seed supply

The three main requirements to be made for seed are:

1. Reasonable health standard.
2. Tubers in a physiological stage that results in rapid emergence with sufficient stems and so that good haulm development may be expected.
3. Reasonable ratio between seed and ware price.

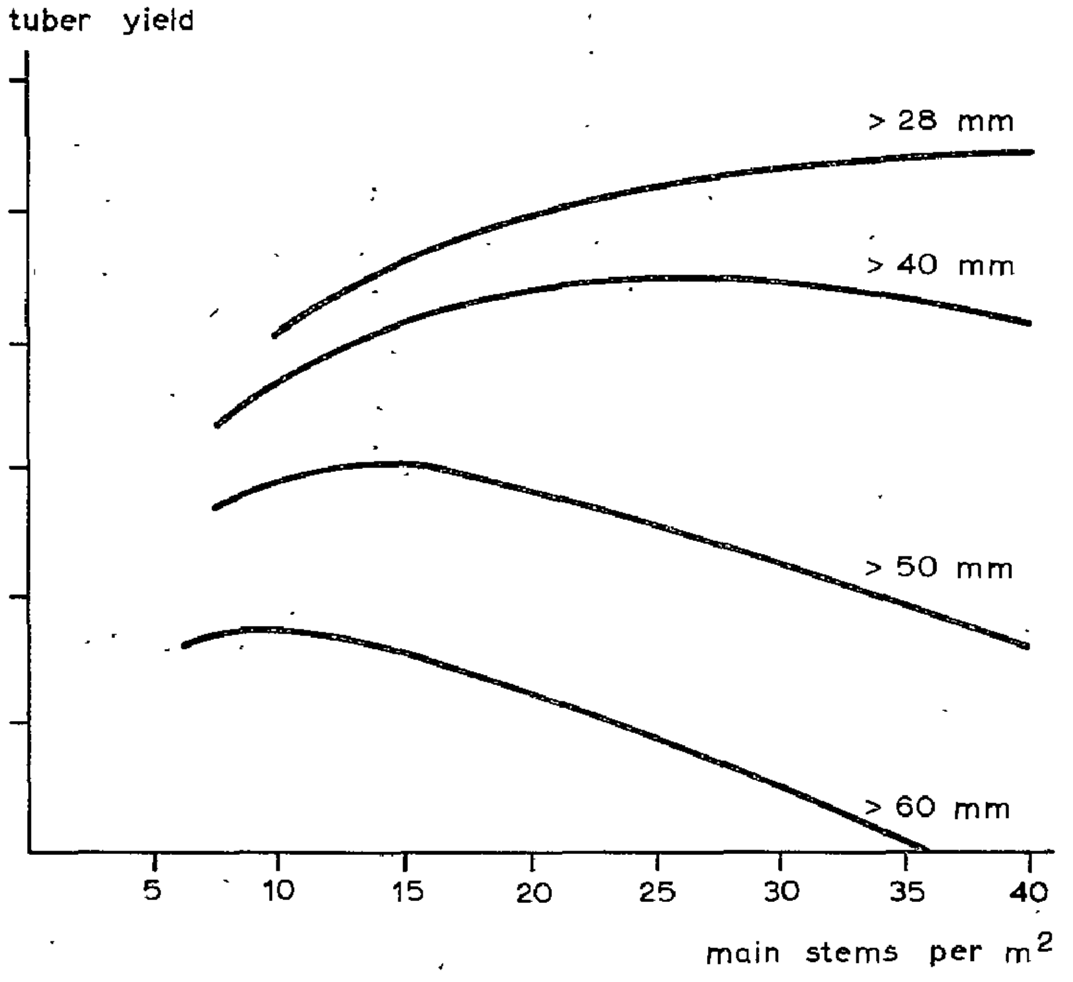

FIGURE 2. Relationship between number of main stems and yield and tuber size (mm). Derived from data of Reestman and Bodlaender.

- TUBER SIZE
  - yield
    - length of growthperiod
    - tuber growth/day
  - number of tubers/m2
    - number of main stems/m2
      - number of sprouts planted/m2
        - number of sprouts/tuber
          - seed tuber size
          - pregermination treatment
        - number of tubers planted/m2
      - seed bed conditions
      - method of planting
      - firmness of sprouts-pregermination treatment
    - number of tubers/main stem
      - number of main stems/m2
      - variety
      - soil type and structure
      - condititions at tuber initiation

FIGURE 3. Factors which influence size of tubers at harvest.

The aim of reasonable health standard is 1) to avoid introduction of dangerous potato diseases – especially soil-born organisms that can be transmitted with the seed and 2) to achieve a good yielding crop. This means that all must be done to prevent spread of dangerous potato diseases with the seed. For such diseases no tolerance can be accepted. Another question is the level of infection of the seed with diseases, that do occur within a country. This level may not be too high because these diseases decrease the yield. If the desired level of infection should be very low, price of the seed will be too high. For virus diseases we will discuss this in more detail.

The effect of virus diseased plants on tuber yield is fairly well known in temperate zones (Fig. 4). The decrease in yield is determined by the type of virus and the crowding coefficient of the crop. The effect of high temperature on the yield of virus diseased plants is not so well known. There are indications that decrease in yield by virus infection is stronger under high temperature condition than in temperate zones.

For viruses that restric haulmgrowth markedly, we assume that D= 1/2H and that for viruses that give only very small poor plants D=1/3H (explanation D and H see Figure 4).

Not under all circumstances does seed with very high health standards give the best financial return. The extra cost of such seed must be less than the extra financial return obtained by the higher yield.

Figure 5, derived from Figure 4 shows the points where the reduction in financial return through virus infection is in balance with the price difference of the seed used and seed producing less than 1% virus diseased plants. This figure shows clearly that if price differences are large (expressed in ware price) between ware and healthy seed, seed with much lower health standard for virus diseases must be accepted only for financial reasons.

Virus diseases are not the only diseases. Fungi, bacteria and other pests that can be transmitted with the seed, affect yield also. No accurate data are available for these diseases, so we will not discuss them.

It is evident that seed multiplication in a country pays for itself if the following requirements are met:

1. No occurrence of dangerous potato diseases that may not be spread to healthy regions.

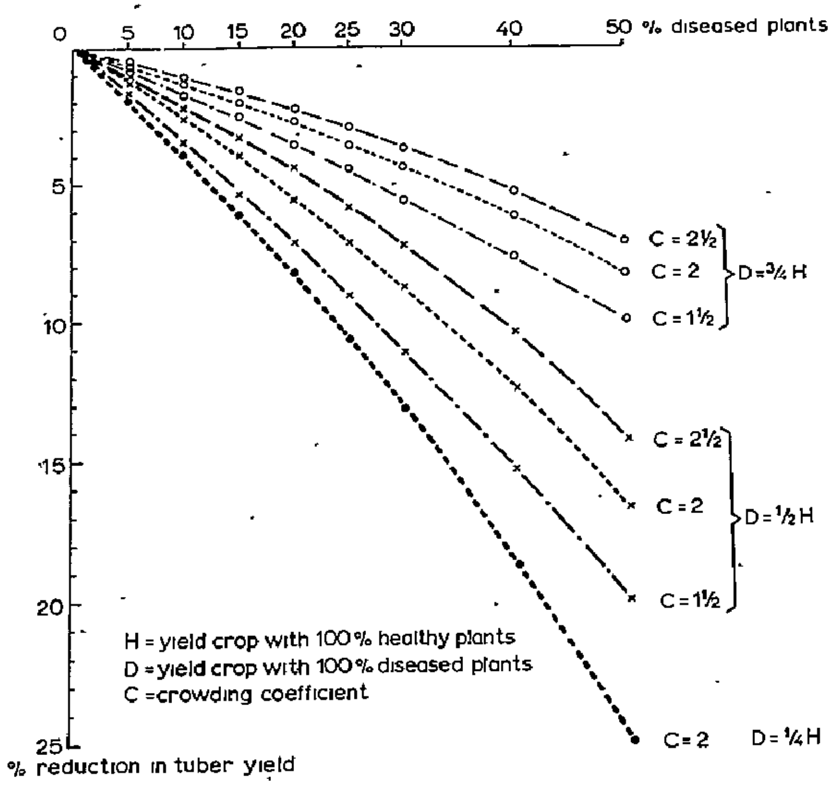

FIGURE 4. Yield reduction in relation to percentage of plants with virus infection, to type of virus and to the crowding coefficient (derived from data of Reestman; 1970).

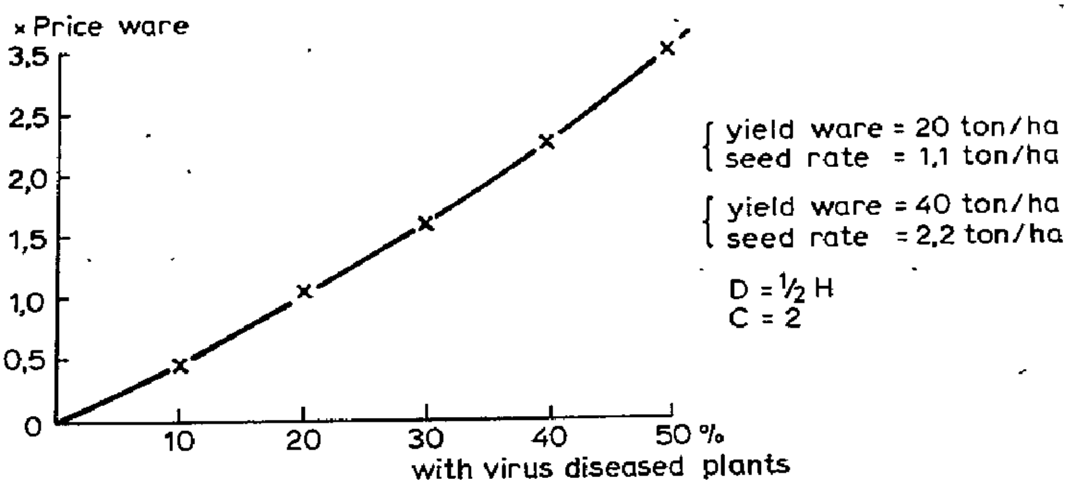

FIGURE 5. Difference in seed price (expressed in terms of ware price) between seed with or without virus infection in relation to the reduction in financial return resulting from the use of seed with virus infection (derived from Figure 4).

2. Reasonable control of virus infection.

3. Reasonable control of fungal and bacterial diseases that can be transmitted with the seed.

4. Adequate storage conditions to deliver the seed in optimal physiological state to ware growers.

5. Farmers who know how to grow potatoes.

6. Scientists who attend the multiplication.

We all will agree that it is much better to start with a simple programme and make it more complete with the years, than to start immediately with a fairly complete programme.

With simple methods much can be achieved. The methods developed in Northern countries must be adapted to tropical conditions. An important point is also the storage condition of the seed. Storage conditions must be adapted to the desired physiological age of the seed tuber at planting. More information on this subject for tropical conditions is needed.

With these few examples I have tried to show you that much more research could be done in tropical countries to improve the growing methods. Several methods developed in the temperate zone can be applied also in tropical zones if they are adapted to these conditions. More exchange of results and more coordination of such research could be useful.

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ADAPTATION OF THE POTATO TO THE WARMER GROWING AREAS IN INDIA

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Although the potato originated in the tropics, its potentialities were exploited mainly in temperate regions. Undoubtedly it did move to countries such as India, in the tropical and sub-tropical regions, but the levels of production in the warmer areas in these regions compare poorly with those in the temperate region. To a point, this is to be expected as the crop is best adapted to cool climates. High temperatures in early stages of plant growth or at planting time affect the crop stand and growth habit of the plant. Warmer conditions during periods of active growth and tuberisation reduce the tuber yields. Temperatures between 15–20° C are close to optimal for balanced growth and tuberisation. The net supply of carbohydrates available for accumulation in tubers diminishes progressively with rise in temperature above about 20° C, and is practically nil above 34° C (3). In India, high temperatures towards the maturation phase of the crop predispose the tubers to infection with the charcoal rot fungus (9).

Extent of the Problem in India: In the high hills of India, altitude modifies the effect of latitude and the temperatures remain below 20° C during the potato crop season, as in the temperate-regions. The position is much different in the mid-hills, plains and plateau areas. In the North-Western plains (sub-tropical zone), the early and the autumn crops in the early stages are exposed to high temperatures. The temperatures become quite favourable during November but fall off rapidly in December until frost kills the crop pre-maturely. The spring crop suffers in the tuber enlargement phase from high temperatures. In the North - Central and North - Eastern plains too, the early and the main crops start off at relatively high temperature till the later part of October; high temperatures also prevail towards the end of the crop season. In the tropical plateau region, in peninsular India, the rabi (winter) crop is exposed to temperatures above 20° C throughout; and the rainy season crop grows under

still warmer conditions. In the strictly tropical plains, the temperatures are still higher.

Possible Approaches to the Problem: The performance of the crop in warm areas could be improved, through two possible ways, 1) adoption of agronomic practices such as use of shade or mulches, pre-sprouting of seed, and 2) use of short duration or heat-tolerant varieties. The performance of an early crop was improved by planting in the shade of a legume, and removing the shade crop by the time the sprouts emerged (8). Alternatively, straw mulches could be used. Shading or mulching reduces the soil temperatures, but its beneficial effect is limited to a short period till the crop emerges. A practice such as pre-sprouting which gives the crop a good start, and greening which prevents seed decay, are also expected to be helpful. Short duration varieties, though necessary in the absence of something better, offer a partial relief as the yield is limited by the short growing season.

If varieties which can resist high temperatures could be bred, the growing season of the crop could be prolonged at most locations and the yielding power of the crop could be improved. Consequently, the cultivation of the crop could be extended beyond the existing frontiers and the area under the crop in the existing tracts could be increased. This would obviously reduce the strain on the transportation system, as the large scale movement of the potato containing large volumes of water, over long distances could be avoided. Is this possible? Differential responses of potato genotypes to temperature, as indicated by the preliminary studies at the Central Potato Research Institute (CPRI) and elsewhere suggest that the problem though difficult is perhaps not insurmountable. The progress of studies at the CPRI on this problem is reviewed here:

Earlier Studies on the Selection of Heat Tolerant Varieties: In the Fifties, field trials were conducted by the Institute in cooperation with the State Dept. of Agriculture, Madras (now Tamil Nadu) with a selected set of hybrids with a view to exploring the possibility of locating one or more hybrids which could grow and tuberise in the warmer regions (1). In these trials two hybrids namely, O.N. 2186 and O.N. 2145, were found to do well at Koilpatti in the extreme south of the peninsular Indian plains. Another approach which was adopted at the Institute was to select suitable material from the wild species *S. chacoense* by inbreeding. By repeated selections among inbred progenies certain hybrids were selected with promise for growing in warmer areas; however, the tubers of these contained the alkaloid solanine, which imparts bitter taste (1).

Further attempts were made to develop varieties resistant to heat. Khanna (4,5) screened selections from the progeny of crosses of selected parents for tolerance to high temperatures, by subjecting their clonal populations to 45°C day temperature and 30°C night temperature for 15 days and thereafter allowing them to tuberise under normal temperatures. Yield assessment of the heat tolerant selections was made at Patna (Bihar). The performance of selected breeding materials was determined at Coimbtore (Tamil Nadu) by the State Department of Agriculture. This work resulted in the release of a hybrid under the name "Co-Simla", which was considered to be heat-tolerant (2). However, the potentialities of this variety have not yet been realized commercially.

Current Studies Based on Selection of Day Neutral Types: The programme of breeding varieties specifically for adaptation to warmer regions has been reoriented recently. The present approach is based on the development of a criterion, whereby a large population of seedlings can be screened for its possible adaptation to warmer conditions. Such a criterion has emerged from the studies on the photoperiodic response of potato varieties and the establishment of a relationship that exists between photoperiodic response and photorespiration. Purohit (6) differentiated genotypes, as qualitative or quantitative short-day types or day-neutral, with reference to tuber induction. On the basis of the present concept of photoperiodism, varieties with strict day length requirement tuberising only below a critical day length, are qualitative; varieties having a potential to tuberise under both extremes of photoperiod with only delay in expression under longer days, are quantitative; whereas varieties which tuberise within the same period under both long and short days, are neutral. A study was then made of the photorespiration rate of three potato cultivars , one each of the qualitative short-day, quantitative short-day and day-neutral hybrids with respect to tuber induction. Photorespiration was maximum in the qualitative short-day and minimum in the day neutral hybrids (7). It is to be expected that minimization of photorespiration helps in increasing the availability of net photosynthates and varieties which are day-neutral with respect to tuber induction may also have higher yield potential. Such varieties may therefore not only have wider adaptability because of their capacity to tuberise over a wide range of temperatures (as well as day - length conditions) but may also give increased yields because of higher photosynthetic efficiency (Purohit and Upadhya, unpublished).

The basic studies are being utilized to isolate day-neutral genotypes from among seedlings at the earliest possible stage of the plant breeding programme. For such screening the seedlings are being tested under two durations of light, viz., 1) continuous illumination for 24 hrs. and 2) 8 hrs.

light and 16 hrs. darkness. Genotypes or seedlings which tuberise at the same time under both sets of conditions are true day-neutrals or insensitive to day length (10). With this technique, over 80,000 hybrids resulting from different cross combinations were screened and about 83 day-neutral genotypes isolated. These selections are under multiplication and initial evaluation studies. Some of the genotypes along with released varieties are being tested in the off season, by planting them in preliminary trials by April 20, 1972 at Khed-Poona. The temperatures have been exceptionally high, around 40° C during the day and 28-30° C at night up to the middle of June.

Under another project, mutants of established varieties are being screened for selection of those with day-neutral reaction. Day-neutral mutants of the culture "O.T." have been isolated (11). In an adaptative trial at Simla in summer, 1972, under conditions of relatively warmer and longer days (temperatures up to 35°C and day-length of 14 hrs.) the day neutral mutants of "O.T." yielded up to 480 g. of tubers per plant in 85 days after planting, whereas the released varieties such as Kufri Chandramukhi and Kufri Jyoti produced smaller yield.

The foregoing preliminary studies have given promising results and suggest that the selection of day-neutral genotypes might pave the way for developing varieties adapted to warmer areas. Incidentally, such varieties will also do equally well in another season or another area, with dissimilar conditions of day-length. For example, in the plateau regions of India, two crops of potatoes (one in winter and the other in the rainy season) are grown, and seed is often obtained from higher hills where the crop is grown under longer day conditions.

Day-neutral types will be subjected to further evaluation for yield and quality characters. The best ones will ultimately be tested in the warmer region. The relative economics of the potato with the use of more heat tolerant varieties will be worked out in comparison with alternative crops in the appropriate cropping patterns.

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REPORT OF THE COMMITTEE ON CIP PROGRAM & OBJECTIVES

REPORT OF THE COMMITTEE ON CIP PROGRAM AND OBJECTIVES FIRST SYMPOSIUM, JULY 17 - 19, 1972

The General Director of the Centro Internacional de la Papa, Dr. Richard L. Sawyer, appointed a committee to make suggestions concerning the program of CIP, based on information derived from the Symposium on Key Problems and Potentials for Greater Use of the Potato in the Developing World. These recommendations were to be included in the proceedings of this Symposium.

Those appointed to the committee were Dr. Edward R. French, President of the Latin American Phytopathological Society (A.L.F.), Dr. Roger Rowe, Leader of IR-1 Project U.S. Department of Agriculture, Dr. Robert Plaisted, President of the Potato Association of America, Dr. Hans Ross, Professor Max Planck Institut Germany, Dr. Mukhtar Singh, Director of the Potato Institute of India, Dr. Date van der Zaag, Secretary and editor of the European Potato Association, Dr. William Black, British Team working with potatoes in Kenya (absent).

The committee met for lunch on July 18, at which time it was decided to only exchange ideas at that time and meet again during the afternoon of July 19 at CIP headquarters after the sessions were over. It was also decided to use as a base for analysis and recommendations the documentation on CIP that was prepared for the Technical Advisory Committee of the Consultative Group for International Agricultural Research.

The committee met at 2:00 p.m. on July 19. The first action was select Dr. Rowe as Secretary. Also present at the meeting as invited participants were Dr. S. C. Litzenberger, USAID, Dr. J. Niederhauser, CIP, Dr. P. Accatino, Chile, and Dr. V. Umaerus, Sweden.

The committee gave its strong backing to the program presented in the documentation. The following suggestions emerged from the discussions and are presented here to lend weight to the program being developed.

- That CIP make every effort to continue a program for testing potato clones for resistance to late blight in the Toluca Valley of Mexico.

- That CIP emphasize in its germ plasm collection the cultivars that can be collected in Latin America and that CIP publish as frequently as possible a listing of the stocks and the screening data that are available.

- That in instances where core projects can be best done, from the technical and financial standpoint, in locations other than at the Center, this should be done. A project may be located away from the Center because of biological requirements or the existence of a unique facility or capability.

- That CIP add an entomologist to its projected staff and develop a research program on detecting resistance to insects. It is anticipated that insect problems will be severe in the lowland tropics.

- That research on cultural practices, storage, and general agronomic practices be developed as part of the core program.

- The committee feels that newly trained Ph.D's from developing countries return immediately to their national responsibilities. Post doctorates can be used to develop scientists from more developed countries for foreign work.

- That every 3 years the Director (or Board of Directors) of this Center appoint a committee to review the scientific activities of the Center.

P. Roger Rowe
Secretary

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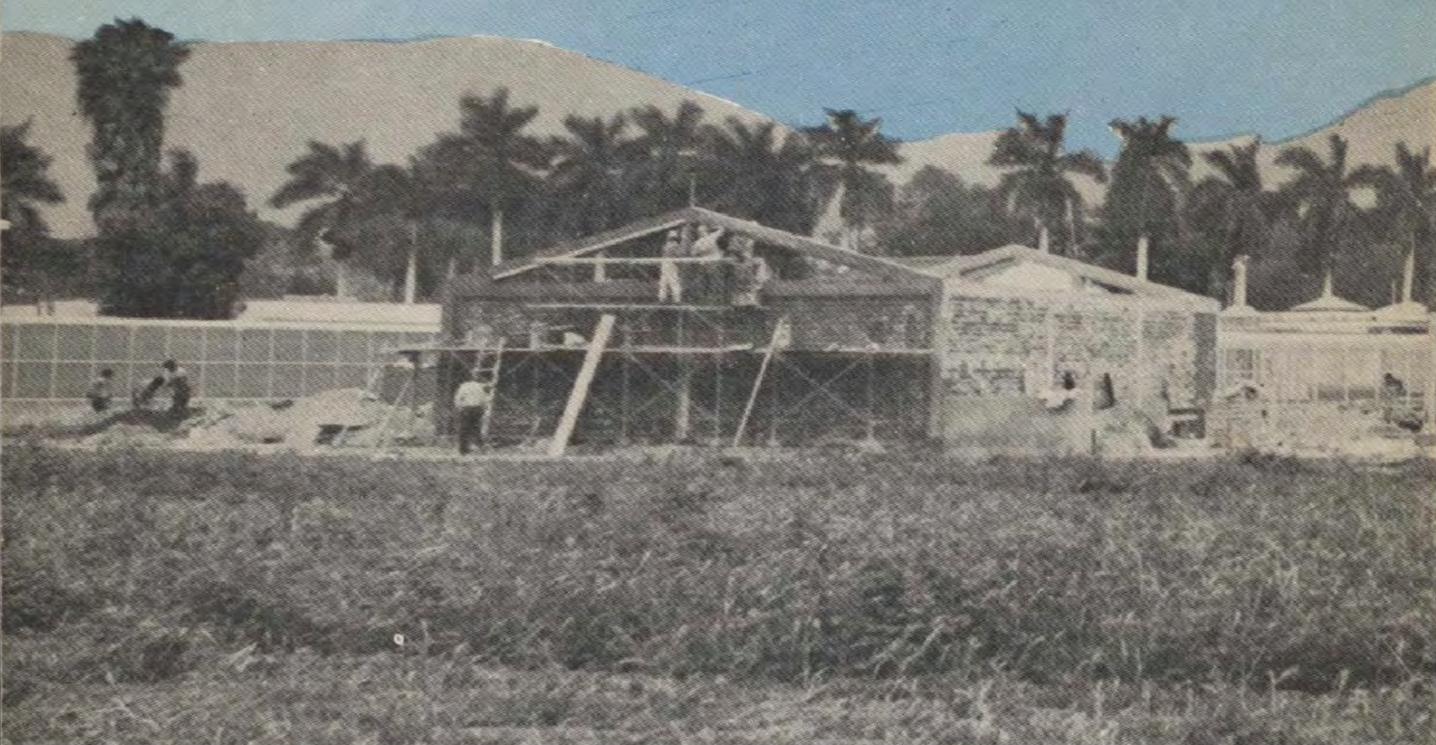

COVER, LEFT TO RIGHT: SCREEN-HOUSES, STORAGE, HEADHOUSE AND OFFICE - LABORATORY BUILDING OF C.I.P.